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MILITARY GYMNASTICS.

NOTHING is more recommendable and more useful than gymnastics. It is, says a distinguished and competent doctor, an exercise that has for an object the regulation of the motions of the body and the development of certain muscles for better assuring the operations of the organs. Gymnastic exercises, when they are well understood, favor the circulation, excite the nutrition and the absorption and render the secretions more abundant and the cutaneous perspiration more complete. Gymnastics, moreover, is a powerful sedative of the nervous system.

There is still more to be said. Gymnastics, especially when one begins to practice it in youth, at the age of physical development, contributes toward increasing the energy of the arms and legs and the agility of the body. The young persons who exercise therein with perseverance and ardor will soon experience a feeling of the progress that they are making through practice.

For some years past the taste for physical exercises has been greatly developing in our schools, and those of our young people who practice them will say that they find themselves all the better for them. We can speak of this knowingly, since we have always had a passion for bodily exercises, such as gymnastics, swimming, fencing, etc., and have kept in mind, as among the most pleasant remembrances of our youth, the happy hours that we devoted to the above named sports.

In the army, the practice of gymnastics is also being largely developed, to the favor of the military schools, which furnish the army with excellent professors. We have already described our military school of gymnastics and fencing of Joinville-le Pont, near Paris, and shall now say a few more words about it in giving a reproduction of some photographs of the exercises that can be seen there. If our readers will attentively examine Figs. 1, 2 and 3, they will see from the attitude of the gymnasts that at this school it is known how to form soldiers who have biceps and who are not wanting in suppleness and agility. The exercises that we here show, such as parallel bars (Fig. 1), vaulting (Fig. 2) and the wooden horse (Fig. 3), are the image of the well executed gymnastic exercises that become familiar to the pupils.

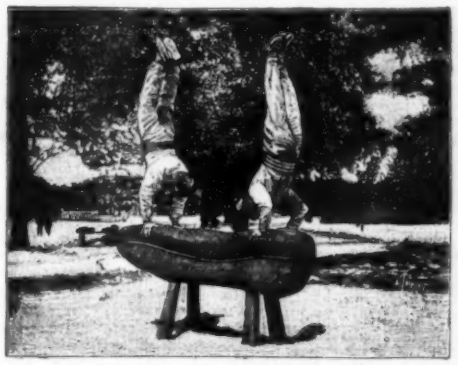


FIG. 3.—EXERCISE WITH THE WOODEN HORSE.

There is nothing, moreover, more interesting to see than the exercises, as a whole, of the School of Military Gymnastics. We have recently received some data regarding another French school of gymnastics and fencing which is as well known as the one above mentioned, and which is rendering as much service to the army. We refer to the Prytanée de la Fleche.

It is a captain of infantry well posted upon the questions under consideration that has communicated them to us. We should like to give his name, but he has requested us to withhold it. We obey, while reproducing the note that he has addressed to us and the photographs that he has sent us of the exercises in vaulting performed by the young pupils of the Prytanée (Figs. 4, 5 and 6).

The captain writes us as follows: The instantaneous photographs that I send you represent various gymnastic exercises executed by youths of from 13 to 15 years, pupils of the Prytanée Militaire de la Fleche.

In all times, long before the law of 1879 made the teaching of gymnastics obligatory, physical exercises, such as gymnastics, fencing, riding and swimming, were held in honor at the Prytanée. The results obtained have always been most remarkable.

Instruction in gymnastics there is given by subaltern monitors, all of them old pupils of the Joinville-le-Pont school, under the direction of a lieutenant. It comprises two sessions of 40 minutes by the pupils of the seventh class to those of the fourth, and a single

FIG. 1.—EXERCISE UPON PARALLEL BARS.

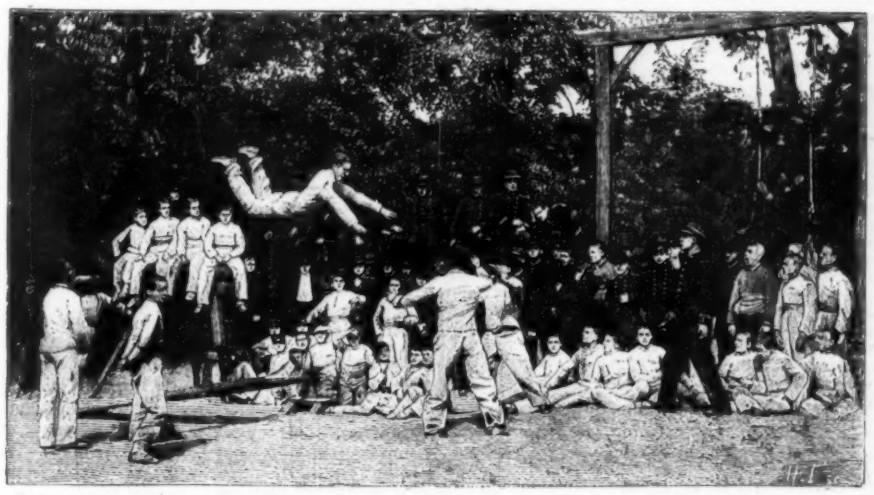


FIG. 4.—EXERCISE WITH THE SPRING-BOARD.

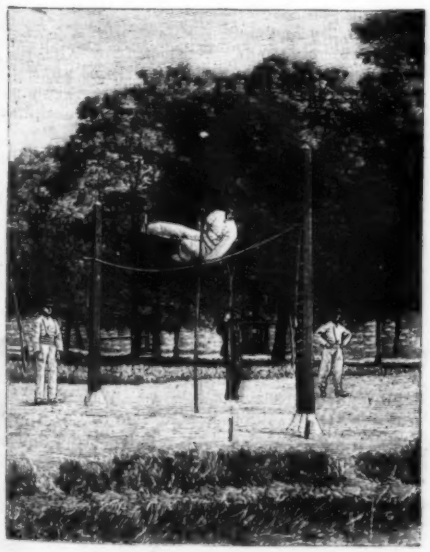
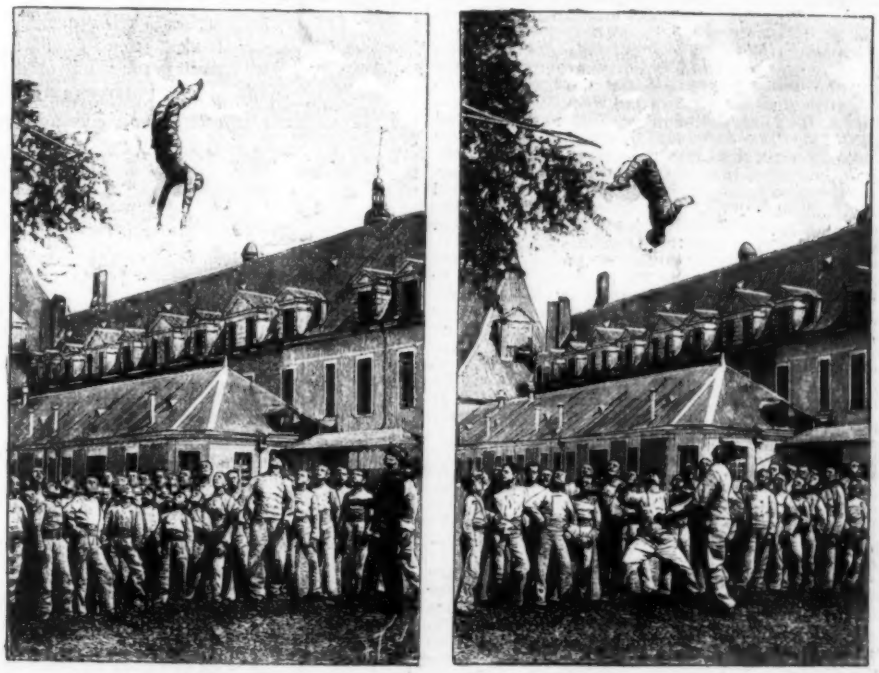


FIG. 2.—EXERCISE IN VAULTING WITH A POLE.



FIGS. 5 AND 6.—EXERCISE WITH THE TRAPEZE.

FRENCH ARMY MILITARY GYMNASTICS.

session of the pupils of the classes above the fourth. This time, as you may see, is reduced to the strict minimum, so as not to infringe upon the class and study hours. But the "brutions"* are, by tradition, fond of corporeal exercises, and so they apply the principles that have been taught them by exercising themselves freely during all the recreation hours, in their play grounds, wherein are found various apparatus. The consequence is that they all become remarkably supple and strong.

All the exercises on the flying trapeze are made only before the monitors, taking, as shown by the photographs, every precaution possible. These exercises develop the qualities of boldness, presence of mind and self confidence to the highest degree. Does it require much more to make an excellent officer, from a physical and moral point of view?—La Nature.

[FROM THE UNITED SERVICE.]

THE SEACOAST GUNS OF THE UNITED STATES SERVICE.

TEN years ago there was not a manufactory in the United States that was capable of producing the steel forgings as required by the Army Ordnance Department in the construction of the new system of seacoast guns, and this department lacked the machinery and appliances for assembling any guns of a greater caliber than eight inches To-day there are at least two steel factories that are able to produce forgings as required, and the Ordnance Department possesses a gun factory of sufficient capacity to allow of the guns of all calibers being assembled as fast as the forgings are provided.

Before proceeding to a description of the progress of the art of gun making and of our present armament, some few explanations may be necessary to make the subject clearer to the non-professional reader.

The "ballistic power" of a gun is determined by the kinetic energy of the projectile as it leaves the muzzle of the gun. Energy, or the capacity to do work, is measured in foot pounds, or for large measures, foot tons (long tons). A foot ton is the amount of work consumed in raising two thousand two hundred and forty pounds one foot, or, the same thing, raising one pound two thousand two hundred and forty feet. One "horse power," as is well known, corresponds to an expenditure of five hundred and fifty foot pounds of work in a second of time.

Assuming always that a gun has been thoroughly tested as to durability, a fair basis of the comparative efficiency of different guns may be obtained by dividing the ballistic power by the weight of the gun. This quotient, taken in connection with the cost per pound of manufacture, gives all the economical data desired.

The powder charge in a gun upon being ignited is converted into gases which exert an enormous pressure in all directions, and the walls of the gun must be strong enough, not only to withstand the pressure, but also to allow the molecules of the metal to assume their original positions when the straining force ceases to act—in other words, the powder pressure must not exceed the "elastic limit."

The ideal gun, both as regards economy and efficiency, is one in which the strain due to the pressure of the powder gases is transmitted through the body of the gun, so that the stress at the exterior surface is zero, and that the metal at no point from the interior to the exterior is strained beyond the "elastic limit." Assuming a fixed allowable maximum pressure, the ideal charge of powder in kind and weight is that which gives the greatest velocity and is entirely consumed at the exact instant that the projectile leaves the muzzle.

In the United States service all of the guns, with three exceptions, are breech-loading, built-up, forged steel constructions. The gun is assembled, and the theoretical principles of gun construction fulfilled by shrinking hoops of varying diameters upon a primary tube. The exceptions are one type of the 12-inch mortar, which has a cast iron tube, and the 3·6-inch and 7-inch mortars, which, on account of the low pressure employed, are composed of single tubes of forged steel.

The service guns are classified as field, siege and seacoast guns. This last class, the one with which we are principally concerned, includes the following calibers of rifles: 8, 10, 12, and 16-inch, and a 12-inch mortar. All pieces of these calibers are indifferently called "high power" guns. For evident reasons, the manufacture of these guns began with the smallest—the 8-inch. The first one of this caliber was completed in June, 1886. The tube and the jacket (the largest and most important hoop) were procured from Whitworth & Company, England, and the hoops and forgings for the breech mechanism from the Midvale Steel Company, Philadelphia. The second 8-inch rifle was completed at the Watervliet gun factory in 1890, and was made entirely of American steel.

The action and recommendations of the "Endicott Board" as it is called, gave an immense impetus to the domestic manufacture of gun steel. This board, composed of the Secretary of War, prominent army officers, naval officers and civilians, was appointed by President Cleveland in 1885 to formulate definite plans of national defense. The total number of guns required and the estimated cost of armament were determined by the board, and it was recommended that the work be carried on uniformly and progressively by means of successive yearly appropriations.

The total cost of fortifying the twenty-seven principal ports of the United States was estimated at $127,000,000, of which $28,500,000 was to be allotted for guns and mortars. The board recommended that $15,000,000 (one-half for the army and one-half for the navy) be made immediately available for the purchase of steel-gun forgings.

While the great steel manufacturers of the country were increasing their facilities in order to be prepared for the new industry of gun making, the chief of ordnance was earnestly urging Congress to appropriate a sufficient amount of money for the construction of an army gun factory. Congress, in 1888, established the home manufacture of modern guns on a firm basis by appropriating $700,000 for the erection of a gun factory at Watervliet, New York, $1,500,000 for the purchase of steel forgings for high-power guns and $200,000 for the purchase of 12-inch breech-loading mortars of cast iron hooped with steel, with the proviso, in all cases, that the contracts should be made with responsible steel manufacturers, citizens of the United States.

The Bethlehem Iron Company and the Midvale Steel Company were the bidders for the manufacture of gun forgings, the former receiving the contract.

The Midvale Company received the contract for the manufacture of the steel hoops and breech mechanism forgings for the mortars, and the Builders' Iron Foundry, of Providence, Rhode Island, the contract for the manufacture of the cast iron bodies and for finishing and assembling the mortars. It has already been remarked that these mortars formed an exception to the type adopted, but it was found that the cast iron bodies were of sufficient strength, besides being much cheaper than steel. All steel mortars of the same caliber are now in process of construction, and, as they are much stronger, they possess a higher ballistic power.

Work in the army gun factory was begun in December, 1888. In accordance with the plan of progressive armament recommended by the Endicott Board, the chief of ordnance designed a factory that would allow of an annual output as follows: Six 16-inch, ten 12-inch, fourteen 10-inch and twelve 8-inch guns. As the work advanced, it was decided to divide the factory into two wings, the south wing being reserved exclusively for the manufacture of 12-inch and 16-inch guns. The factory is now completed, with the exception of the installation of some of the machinery for the manufacture of 16 inch guns.

Each of the type guns is composed of one tube, one jacket, a number of hoops, assembling rings, pins and caps and the various parts of the breech mechanism. The hoops are designated by letters of the alphabet according to their position in the gun, the different hoops of each series being distinguished by numerals. The forgings, as received from the contracting steel manufacturer, are, as a rule, rough finished, and are turned to their exact dimensions at the gun factory. The amount of expansion of the parts by heat is determined beforehand, and depends upon the size of the piece to be heated and the time required to get it into place on the gun. As a rule, the parts are not heated above a temperature of 500° F. The different parts, beginning with the jacket, are successively slipped over the gun and shrunk in place by cooling them with running water.

The breech mechanism adopted for the type guns resembles in most respects the French or "interrupted screw" system. The breech block has the same relation to the breech that a screw bolt does to its nut. Half of the threads of both surfaces is cut away in sectors to the same depth as the thread. Upon closing the breech block the threaded sectors of the block slide smoothly over the slotted sectors of the breech until a point is reached where a partial turn equal to the width of one sector will engage the threads and complete the insertion.

The very fact that the breech mechanism can be easily operated by hand proves that there must be apertures which would permit the escape of the powder gases to the rear unless some means were taken to prevent it. This is effected by means of a "gas check," which consists essentially of a highly elastic steel cup inclosing a conical spindlehead, the whole arrangement being attached to the head of the breech block. The pressure of the powder gases upon the spindlehead expands the walls of the cup outward against the bore.

Upon the cessation of the pressure, the elasticity of the parts allows them to resume their original positions. The most familiar as well as the simplest form of a "gas check" is the metallic cartridge case that holds the ammunition for the ordinary breech-loading small arm.

The table above gives some of the most interesting figures relative to the seacoast guns of the United States service. It has been assumed that some form of what is known as "brown prismatic" powder is to be used with all of these guns. Recent experiments have shown that certain varieties of smokeless powders will give much higher velocities than those tabulated without any increase of pressure, and it seems to be a question of only a few years before smokeless powder will be adopted for all classes of modern ordnance.

W. E. ELLIS,
Lieutenant, U. S. A.

	Sea Coast Guns, Steel.					Sea Coast Mortars.	
	8 inch.	10-inch.	12-inch.	12-inch model 1892.*	16-inch.	Cast iron steel hooped.	Steel.
Weight (pounds)	32,486	67,200	116,480	128,719	280,000	31,920	29,120
Total length (feet)	23·21	30·6	36·66	40	49·07	10·75	11·76
Maximum resistance to powder pressure (pounds per square inch)	51,980	53,000	53,000	62,640	53,000	29,490	50,200
Weight of powder charge (pounds)	125	250	450	487	1060	80	105
Weight of projectile (pounds)	300	575	1000	1000	2370	{800 {1000	{800 {1000
Muzzle velocity (foot-seconds)	1950	1675	1975	2100	1675	1020	1140
Muzzle energy (foot-tons)	7907	15,548	27,070	30,570	64,084	5770	7207
Penetration in steel at muzzle in inches	16	20·4	24·9	27·1	3 38	8·2	9·7

* The 12-inch rifle, model 1892, differs from the other types in the material of the tube, which is made of nickel steel.

DETROIT RIVER DREDGING—LARGE BOWLDERS.

BOWLDERS that would make a shipmaster's hair stand on end are being taken out of the channel between Ballard's Reef and the Lime Kiln cut, Detroit River. Of course, many of them were embedded deep into the gravel and sand on the bottom of the river and are not obstructions to navigation under the deepest draught at present available thoughout the lakes, but the work of removing them is made a part of the 20 foot channel project. Capt. McKay, of the Lake Carriers' Association, spent a few days recently on the Detroit River making inquiry regarding the channel improvements. Contractors have been at work since last fall in the vicinity of Ballard's Reef and the Lime Kilns removing these bowlders under the direction of United States Engineer Kahlman. For 300 feet east and west of a line centering the Grosse Isle ranges and the Lime Kiln cut the channel is being carefully gone over with a view to removing all bowlders, so that dredging later will provide a 20 foot channel, 600 feet wide, from Ballard's Reef to the cut. As yet the work has progressed for a distance of little more than half way down to the cut on the west side of the line, but some 700 or 800 bowlders have been removed. One of them contained nearly 100 cubic yards. It was raised with two scows and when dropped later in an out of the way place near Grosse Isle there was only 14 feet of water over it, although the depth all around it was 23 feet. These big stones are raised with "devil claws," which are clamped over them, but as there is a long job yet before the contractors, with prospects of many larger bowlders to be found, it may be necessary to resort to drilling and the use of dynamite.

In that part of the river between Bois Blanc Island and the Bar Point lightship all obstructions are removed, and as a part of the 20-foot channel this stretch is practically completed. This gives a clear channel for a distance of 400 feet east and west of the course followed between Bar Point lightship and the Amherstburg ranges. Pontiac shoal, opposite the little school house on Bar Point, was one of the bad spots removed in dredging this stretch of the river. The character of the bottom here was gravel, bowlders and stone that had the appearance of having been quarried at one time. This latter material is thought to have been ballast brought to the mouth of the river thirty years or more ago by small vessels from Ogdensburg and thrown overboard by them before going up the river to load timber and other freight.—Marine Review.

[FROM THE INDEPENDENT.]

THE INTERCONTINENTAL RAILWAY COMMISSION.

By E. Z STEEVER, Secretary of the Commission.

THE Intercontinental Railway Commission is the outcome of the International American Conference, which convened in Washington in 1889. The Committee on Railway Communication of that body submitted the following report, which was adopted.

REPORT OF THE COMMITTEE ON RAILWAY COMMUNICATION.

The International American Conference is of the opinion:

First.—That a railroad connecting all or a majority of the nations represented in this Conference will contribute greatly to the development of cordial relations between said nations and the growth of their material interests.

Second.—That the best method of facilitating its execution is the appointment of an international commission of engineers to ascertain the possible routes, to determine their true length, to estimate the cost of each, and to compare their respective advantages.

Third.—That the said Commission should consist of a body of engineers of whom each nation should appoint three, and which should have authority to divide into sub-commissions and appoint as many other engineers and employes as may be considered necessary for the more rapid execution of the work.

Fourth.—That each of the Governments accepting may appoint, at its own expense, commissioners or engineers to serve as auxiliaries to the sub-commissions charged with the sectional surveys of the line.

Fifth.—That the railroad, in so far as the common interests will permit, should connect the principal cities lying in the vicinity of its route.

Sixth.—That if the general direction of the line cannot be altered without great inconvenience, for the purpose mentioned in the preceding article, branch lines should be surveyed to connect those cities with the main line.

Seventh.—That for the purpose of reducing the cost of the enterprise the existing railways should be utilized as far as is practicable and compatible with the route and conditions of the continental railroad.

Eighth.—That in case the results of the survey demonstrate the practicability and advisability of the railroad, proposals for the construction either of the whole line or of sections thereof should be solicited.

Ninth.—That the construction, management and operation of the line should be at the expense of the concessionaires, or of the persons to whom they sublet the work or transfer their rights with all due formalities, the consent of the respective Governments being first obtained.

Tenth.—That all materials necessary for the construction and operation of the railroad should be exempt from import duties, subject to such regulations as may be necessary to prevent the abuse of this privilege.

Eleventh.—That all personal and real property of the railroad employed in its construction and operation should be exempt from all taxation, either national, provincial (State) or municipal.

Twelfth.—That the execution of a work of such

* The pupils of the Prytanée are so called in the army.

magnitude deserves to be further encouraged by subsidies, grants of land, or guarantees of a minimum of interest.

Thirteenth.—That the salaries of the Commission, as well as the expense incident to the preliminary and final surveys, should be assumed by all the nations accepting, in proportion to population according to the latest official census, by agreement between their several Governments.

Fourteenth.—That the railroad should be declared forever neutral for the purpose of securing freedom of traffic.

Fifteenth.—That the approval of the surveys, the terms of the proposals, the protection of the concessionaires, the inspection of the work, the legislation affecting it, the neutrality of the road, and the free passage of merchandise in transit, should be (in the event contemplated by article eight) the subject of special agreement between all the nations interested.

Sixteenth.—That as soon as the Government of the United States shall receive notice of the acceptance of these recommendations by the other Governments, it shall invite them to appoint the Commission of Engineers referred to in the second Article, in order that it may meet in the city of Washington at the earliest possible date.

Accordingly the Diplomatic and Consular Appropriation Bill, approved July 14, 1890, contained an item "For payment of the share of the United States of a preliminary survey for information in respect of a continental railway recommended by the International American Conference, $65,000," the President of the United States being authorized to appoint three members of the continental railway commission, not more than two of whom should belong to one political party, and in addition to civil engineers employed by said commission, to detail from the army and navy of the United States officers to serve as engineers under such commission in making a survey for a continental railway.

Invitations having been issued by the Department of State to various Governments of America, and the necessary preliminary arrangements made, the Intercontinental Railway Commission met in Washington, December 4, 1890, and organized for business, Mr. A. J. Cassatt, of Philadelphia, being elected its President.

The Argentine Republic, Brazil, Colombia, Eucador and Peru, Guatemala, Mexico, Paraguay, Salvador, the United States, Uruguay and Venezuela being represented by the following delegates: For the Argentine Republic, Mr. Carlos Agote, Mr. Julio Krause, Mr. Miguel Tedin; for Brazil, Mr. Pedro Betim Paes Leme, Mr. Francisco de Monlevade; for Colombia, Mr. C. Federico Parraga, Mr. Julio Rengifo, Mr. Climaco Calderon; for Ecuador and Peru, Mr. Leffert L. Buck; for Guatemala, Mr. Antonio Batres; for Mexico, Mr. Leandro Fernandez; for Paraguay, Mr. John Stewart; for Salvador, Mr. Benjamin Molina Guirola; for the United States, Mr. A. J. Cassatt, Mr. H. G. Davis, Mr. R. C. Kerens; for Uruguay, Mr. Francisco A. Lanza; for Venezuela, Mr. Luis J. Blanco.

The full Commission remained in session until April 22, 1891, discussing the best means for carrying out the objects for which it had been called into existence. Three surveying parties were organized to undertake the preliminary survey for a railroad intended to unite the existing systems of the United States and Mexico with those of Peru, Chile, Brazil, and the Argentine Republic.

The surveyors having started for the field, the full commission adjourned to await results, having first appointed an executive committee of five members with full power to act during the recess. This committee was to represent the Intercontinental Railway Commission in its relations with the United States Government as well as with other authorities, corporations or persons that might be connected with said commission. This committee, consisting of Messrs. A. J. Cassatt, C. F. Parraga, L. L. Buck, L. J. Blanco, and John Stewart, was clothed with the following powers:

1. The disbursement of the funds pertaining to and that may be received by the Intercontinental Railway Commission.

2. The Executive Committee shall see that the funds appropriated by the United States and the other Governments for the Intercontinental Railway are paid in; and it will also solicit in due time from the same Governments additional appropriations for the same object.

3. The appointment and dismissal of any employes of the Intercontinental Railway Commission.

4. The organizing and sending of additional surveying parties under advice of the Committee on Trade and Resources in regard to the agricultural and commercial conditions of sections to be surveyed.

5. Issuing of necessary instructions to surveying parties and answering all questions and inquiries that may be made by them.

6. To authorize the expenses of the additional surveying parties, those expenses to be upon the same basis and in accordance with those of the parties already appointed.

7. To communicate with the various delegates of the countries represented at this Commission, keeping them posted in regard to the progress of the work and soliciting from them all the information that might facilitate the progress and success of the work.

8. To reconvene the Commission and call the delegates together when sufficient information shall have been gathered by the surveying parties for the furtherance of the projected enterprise.

The Committee has maintained in Washington a central office, from which have emanated the necessary instructions for the prosecution of the surveys and conduct of the general business of the Commission. This office has been under the charge of Lieut.-Commander R. M. G. Brown, U. S. Navy, as Executive and Disbursing Officer, and Capt. E. Z. Steever, U. S. Army, as Engineer and Secretary to the Commission. The Executive Committee, with the assistance of Mr. H. G. Davis, Chairman of the Committee on Finance, and Mr. R. C. Kerens, Chairman of the Committee on Trade and Resources, have met from time to time when circumstances rendered it necessary or advisable to approve the steps already taken or to decide upon more important matters for the future. The President of the Commission has been in constant communication with the office, and has supervised the management of the surveys through that channel.

Of the three surveying parties sent into the field, Corps No. 1, under Lieut. M. M. Macomb, U. S. Army, went to Central America. As the Mexican system of railroads is being extended to the southern boundary of Guatemala, and is now in operation as far as Oajaca, 400 miles south of the city of Mexico, no surveys were needed in that republic. Consequently, the work was commenced at Ayutla, on the northern frontier of Guatemala, and a continuous line of survey run southeastwardly through the Republics of Guatemala, Salvador, Honduras, Nicaragua, Costa Rica, by way of Retalhuleu, Escuintla, Santa Ana, San Salvador, Choluteca, Chinandega, Managua, Rivas, Liberia, and Punta Arenas to the Rio Savegre, where the work of Corps No. 1 terminated. Two years were devoted to making extensive surveys and explorations in this part of the country traversed by the proposed Intercontinental Railway. In addition astronomical, geodetic and meteorological observations were taken, and a large amount of valuable data bearing on the resources of the countries collected. Through this section the construction of a railroad would be practicable and comparatively inexpensive.

Corps No. 2, under Mr. William F. Shunk, went to Quito, Ecuador, and from there surveyed northwardly through part of Ecuador, Colombia, the Isthmus of Panama to the Rio Savegre in Costa Rica, thus connecting with the work of Corps No. 1. From Quito the line runs via Ibarra, Tulcan, Pasto and Popayan at the head of the Cauca River, the valley of which is followed via Cali, Cartago and other points to Antioquia, whence an ascent is made via Canas Gordas across the western cordillera to the Rio Sucio, thence down that stream to its junction with the Atrato, the basin of which is traversed and an ascent made to a crossing of the ridge separating that river system from the Pacific Ocean, thence continuing via Yavisa at the head of San Miguel Bay, the coast line is followed via Panama and David to the Savegre River. Leaving the Cauca Valley below Cartago, a branch line was surveyed via Medellin and Caceres to Cartagena, on the Caribbean Sea, whence easy communication by water could be established with the southern ports of the United States. The section between Quito and Popayan, passing as it does through the very heart of the Andes, would be expensive to construct; but the surveys demonstrate the entire feasibility of the route, with no grades as high as four per cent. From the head of the Cauca Valley grade ceases to be a ruling consideration, and the construction of a road could be effected at a moderate cost. This Colombian region abounds in natural resources, and the Cauca Valley is destined to be at no very distant day one of the richest mineral and agricultural portions of South America.

Corps No. 3, under Mr. William D. Kelley, likewise started at Quito, but worked southwardly through Ecuador and Peru, to the confines of Bolivia via Cuenca, Loja, Cajamarca, Caraz, Cerro de Pasco, and Cuzco to Lake Titicaca. The investigations of this party also show the practicability of constructing a railroad along the central plateau lying between the eastern and western cordilleras of the Andes, and connecting most of the important towns and mining centers situated in the interior of these two republics. In certain portions the building of the line would be expensive, owing to the various deep cañons and the heavy grades rendered necessary by a country so mountainous in character. In other parts, however, construction would be inexpensive, while in some sections, more populous and more level, a railroad would prove remunerative from the local traffic alone.

From the brief account given above of the work already accomplished by the Intercontinental Railway Commission, some idea can be formed of the vastness of the undertaking.

A continuous line of over 4,500 miles in length has been surveyed and pronounced feasible railroad ground by competent engineers. The reports and maps now being prepared in the Washington office will give, when published, information concerning railway possibilities never before offered to the world, and will demonstrate the feasibility of constructing a line that shall connect the systems of the United States with those of the Argentine Republic. Time and money will be required to attain so desirable an end; but the preliminary survey so successfully prosecuted by the Intercontinental Railway Commission will be an important means toward the realization of so grand an enterprise.

Washington, D. C.

VESTIBULE EQUIPMENT.

THE Street Railway Review says quite a change of opinion on the vestibule question has taken place during the year, yet all admit that the vestibule has its disadvantages, and it is a question whether they do not overbalance the advantages. Experience has caused different managers to have different opinions, even in the same localities, one finding them to be of benefit and his neighbor condemning them as useless. The engraving shows different styles of home-made vestibules.

Among the objections to the vestibule are: The requiring persons controlling the motive power of cars to work therein would endanger the safety of such persons in case of collisions, which are of frequent occurrence.

In case of sleet, snow or rain storms, or in extremely cold weather, it would be impossible for the person in charge of the car to safely control the same without having the front windows of the vestibule down, so as not to interfere with his vision, and in such cases the storm would beat in upon him and the vestibule would not give the desired protection.

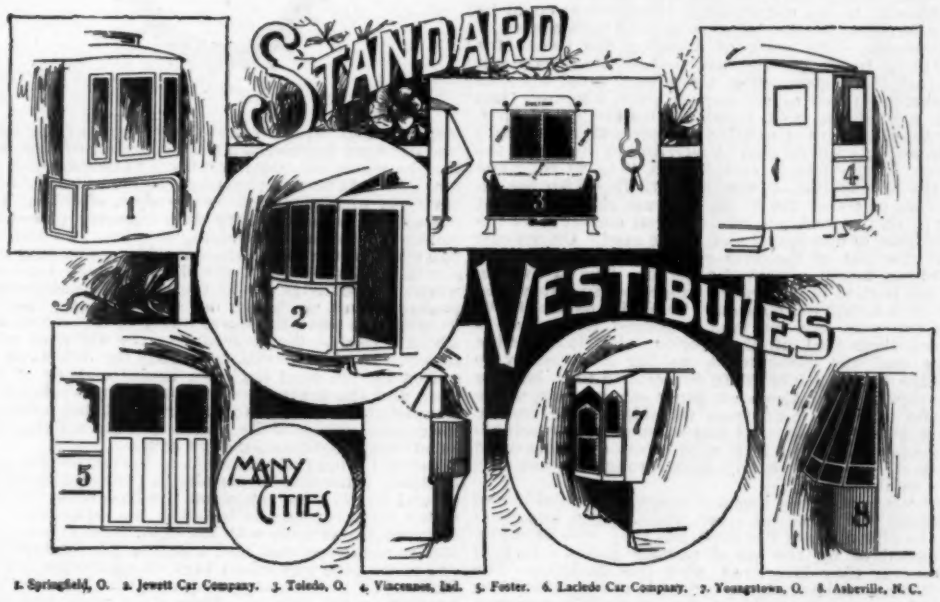
These vestibules would necessarily make accidents much more frequent than now, for the reason that the person controlling a car would be placed in such a position that in stormy weather it would be difficult to see in front of the car, and it would be impossible to see that persons had safely boarded the car before starting, and it would also be impossible for the person in charge of the car to look to either side of the car for the purpose of ascertaining whether the car could safely pass vehicles or obstructions close to the track.

They would prevent the person in charge of the car from seeing passengers coming from side streets who wished to hail the car for passage, and this would be particularly true in stormy weather. It would also prevent the turning of a switch by the person controlling the motor power.

The brake now in use on electric and other roads is in form of a lever, upon which great power can be thrown to stop a car in places of imminent danger. It is most likely these brakes would have to be changed if the vestibules were used, and a brake of the character of that in use on steam railroads or a wheel brake substituted. The same power cannot be used on this form of brake, and this fact is more apparent when it is recalled that on a street car rarely but one hand can be used in applying the brake.

On many cars it will be necessary to have the vestibule on each end of the car, and this would prevent the conductor from caring for the trolley rope.

Many objections might be urged from the standpoint of the public, such as the inconvenience (and, in case of accident, perhaps the danger) of quickly alighting from cars, the inconvenience in boarding cars, preventing smoking on closed cars, slow running and the like.



1. Springfield, O. 2. Jewett Car Company. 3. Toledo, O. 4. Vincennes, Ind. 5. Foster. 6. Laclede Car Company. 7. Youngstown, O. 8. Asheville, N. C.

A LINE OF TWENTY-EIGHT INCH CAST-IRON SUBMERGED PIPES ACROSS THE WILLAMETTE RIVER, AT PORTLAND, ORE.*

By FRANKLIN RIFFLE and ALBERT S. RIFFLE, Ms. Am. Soc. C.E.

THE line of submerged pipes, forming the subject of this paper, is a portion of the main pipe line constructed during 1893 and 1894 to supply the city of Portland with pure water diverted from Bull Run, a mountain stream about thirty miles distant.

With the exception of the submerged section, the portion inside the city limits (about six miles), connecting the high service reservoir on the east side of the Willamette River with the high service reservoir on the west side, consists of cast iron pipes 32 in. in diameter.

Proposals were received for this work three times before the contract was finally awarded. On March 1, 1893, bids were opened for two lines of 24 in. cast iron pipes. All bids were rejected, and it was not until August 15 of the same year that bids were again received; this time for a single line of 28 in. pipes. The specification set forth that bids would be received for both cast iron pipes and riveted pipes of wrought iron or steel. Each bidder was required to submit with his proposal a design of a flexible joint. The Oregon Bridge Company (of which the authors are members)

* Abstract from a paper read March 6, 1895. From the Transactions of the American Society of Civil Engineers.

was the lowest bidder. This firm's bid was for cast iron pipes provided with the well known Ward joint. All bids were rejected. About a month later the Oregon Bridge Company was requested by the Chief Engineer of the Water Committee, Isaac W. Smith, M. Am. Soc. C. E., to submit a proposal for cast iron pipes provided with flexible joints, the design of which had been prepared in his office. This design will be readily recognized as a modification of the Fanning joint (see Fig. 1).

The revised bid of the Oregon Bridge Company was accepted and the contract promptly awarded.

Furnishing Pipes.—After the award of the contract, the contractors requested bids for furnishing the pipes from sixteen of the leading pipe foundries in the United States. As the manufacture of these pipes necessitated special preparations and additional appliances, all but three of the foundries declined to bid. Two of these, the Addyston Pipe and Foundry Company, of Cincinnati, and the Ohio Pipe Company, of Columbus, varied but little in the amounts of their bids, and it was exceedingly difficult to decide between them.

The contract was, however, finally awarded to the Ohio Pipe Company, which agreed to manufacture the pipes in lengths of nearly 17 ft.—4 ft. longer than the Addyston Pipe Company would agree to furnish them. The advantages in favor of the long pipes are obvious. One hundred and twenty-six of these pipes would complete the contract, while 166 of the shorter pipes would be required. In the cost of laying there would be a clear saving of 25 per cent., since the cost is largely, if not wholly, governed by the number of joints. In addition to this there would be a saving of about eight tons of lead and about one hundred tons of freight.

Delivery of the Pipes.—Although it was stipulated in the contract with the manufacturers that the pipe should be delivered at Portland on or before June 1, owing to delays at the shops and to railroad strikes later on, it was August 20 before the last pipe arrived.

The manufacturers took particular pains in loading the cars to secure the pipes thoroughly, the result being that the entire shipment came across the continent without receiving the slightest injury.

The pipes were unloaded from the cars with a two-way derrick, connected with a stone-cutting yard near the east bank of the river, and were then rolled down a skidway to the water's edge, whence they could be transferred to the derrick scow as they were needed.

Dredging.—The work of dredging the trench for the pipes began on the east side of the river about August 1. A stern-wheel steamboat, fitted up with buckets attached to an endless chain operated from one side of the boat, forming a bucket dredge, performed the entire excavation in a perfectly satisfactory manner. As will be seen by referring to the profile the depth of the trench varied from 8 to 23 ft. The width at the bottom was 10 to 12 ft. With the exception of about 250 ft. on the east side and about 300 ft. on the west side, the material consisted for the most part of fine gravel and coarse sand. On the east side the bed of the river consisted of bowlders and hard pan firmly cemented together. The excavation of this portion of the trench progressed so slowly that nearly a month was consumed before it was completed. On the west side soft mud (deposited from a sewer which discharged into the river immediately above the pipe line) was encountered, making it necessary to dredge to a depth of 23 ft. to secure a solid bed for the pipes. Here, also, slow progress was made, owing to the inflow of mud from the sides of the trench. Even after firm material was reached, the trench became partially filled with mud before the pipes could be laid; but they readily sank through the soft mud to a solid bearing.

Occasionally trees, logs and snags were found buried beneath the bed of the river, which added somewhat to the difficulties of the work, but they were promptly disposed of by the use of powder and a snag boat whenever they interfered with the dredging. The hull of a vessel completely buried in the sand was torn into fragments by powder before it could be removed.

The dredge was kept on the line by means of a row of piles driven about 35 ft. apart (except in the channel) above the pipe line at a convenient distance from the trench. These piles were afterward used for keeping the pipe-laying barges on line.

About 18,500 cubic yards of material were excavated with the dredge—an average of about 10 cubic yards per linear foot.

Rejected Pipes.—During the month of August all preliminary arrangements were completed for beginning the work of pipe-laying. The cradle (see engraving) which had been framed on the pipe-laying barges, was in position ready for duty; a number of pipes had been delivered on board the barges and tested in the testing machine, and the contractors were ready to begin laying pipe on September 1, when a letter was received from the chief engineer stating that the local

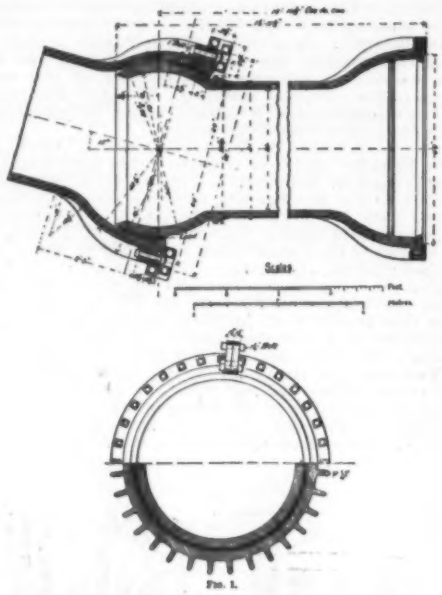


FIG. 1.

inspector had reported that the ball ends of the pipes had not been finished to a truly spherical surface, and that he would require the defects to be remedied before he would permit the pipes to be laid. This discovery of alleged defects in the pipes, after they had passed the inspection of the shop inspector, placed the contractors in an embarrassing position. To turn the ball ends of the pipes again would require the construction of a special lathe, during which time the work of pipe laying would be postponed indefinitely, probably until it would not only be hazardous but foolhardy to begin the work, owing to the sudden and frequent rises in the river during the winter or rainy season. In other words, to remedy the defects as required by the chief engineer, meant a delay of one year, and the contractors were under heavy bonds to complete the work by November 1, 1894, the forfeiture for noncompletion of the contract within the time specified being $200 for each day's delay.

Before taking further action in the matter, the chief engineer consented to permit the contractors to lay several pipes in the trench on the east bank on condition that the joints be tested to his satisfaction. A connection was made with the 32 in. main at once. As fast as each pipe was laid and the joint calked, the end of the pipe was raised high enough to revolve the ball end 15° in its socket, and was then lowered to a bearing in the trench. After eight pipes had been laid in this manner a cast iron cap was bolted to the end of the last pipe, and a pressure gage was attached. Water was then admitted through the gate on the 32 in. pipe line, the water having been supplied by the East Portland Water Works for this experiment. At 10 lb. pressure every joint leaked considerably. The contractors desired that the pressure be increased, but the chief engineer believed the defects could be best demonstrated to exist by using a light pressure. The experiment, however, was continued with an increase of pressure. It was soon apparent that the leakage diminished as the pressure increased, until at 45 lb. pressure it ceased entirely, the eight leaky joints having become absolutely tight.

The contractors were now convinced that they could make the joints of the entire submerged pipe line practically tight as the work progressed, whether the ball ends were defective or not. But after having laid three more pipes a peremptory order from the chief engineer was received to suspend operations until action could be taken by the water committee. The water committee did not meet to consider the matter until a week later. In the meantime the chief engineer formally notified the contractors that his chief inspector had carefully examined the 16 pipes lying on the pipe-laying barges, and, acting on his inspector's report, he had rejected 13 of the pipes as not fulfilling the requirements of the specifications.

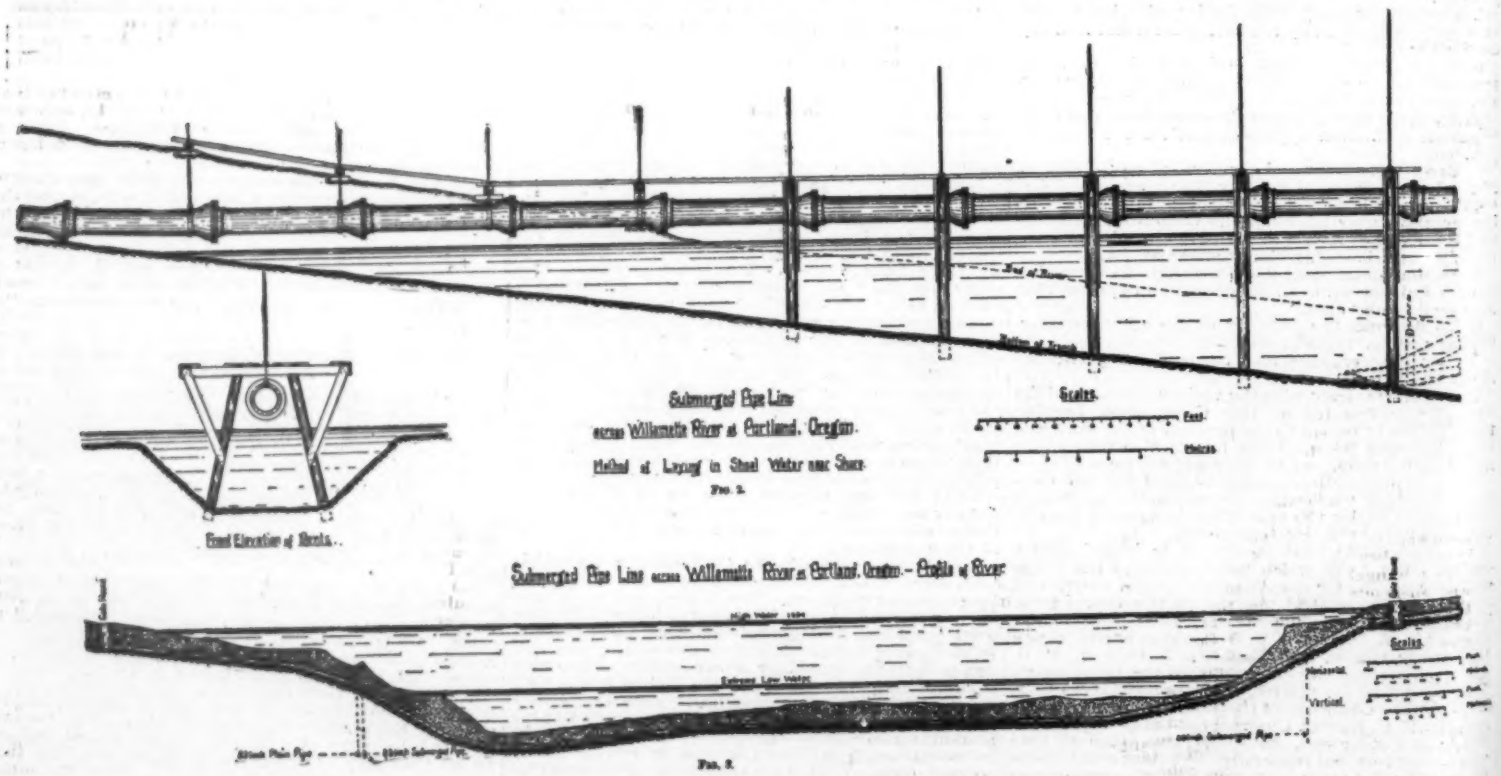
At the meeting of the water committee, the chief engineer took the position that the ball ends of the pipes were not truly spherical, and advised that they should not be accepted until they were made to comply with the specifications. The contractors argued that the lathe work had been performed under the personal supervision of a competent inspector appointed by the chief engineer; that the pipes having been once inspected and accepted through a duly authorized agent, it was unfair to refuse to accept them because a second inspector found fault with the workmanship nearly three months after they had left the shops, and six weeks after they had reached their destination; that in the absence of specifications for the lathe work, the only test to be applied was that of adaptability to the requirements of the contract; that the workmanship on the ball ends was of such a character as to permit them to move in their sockets with the greatest ease while the pipes were being lowered into position, and that whether the joints leaked or not was immaterial so long as they were made tight after the pipes were in the bottom of the trench; and that the test imposed by the chief engineer was contrary to the specifications, the final test being the only one prescribed.

The chief engineer refused to believe that the joints could be "pulled" tight by hydraulic pressure, except under the most favorable conditions, and argued that such conditions would not prevail in the bottom of a trench excavated in the bed of the Willamette River.

The water committee decided to permit the pipes to be laid, and to make the payments as stipulated in the contract, the contractors to be held responsible for all rejected pipes. As, under the terms of the contract, the contractors were held responsible for all the pipes laid, whether perfect or defective, they promptly accepted these terms.

While some of the members of the committee undoubtedly believed the undertaking would prove a success, there is no doubt that the committee was largely influenced by the fact that the returning of the ball ends of the pipes would postpone the completion of the new water system another year, during which time the city would be paying interest on bonds to the amount of more than $2,000,000 without receiving the slightest benefit in return for this outlay.

It is to be regretted that the three accepted pipes were not subjected to the same test as the first eight pipes laid, for the authors confidently believe that they also would have leaked under like conditions. While it is altogether probable that radial inequalities of 1-100 or even 1-1000 in. in the ball end of a flexible joint may be the cause of more or less leakage, on the other hand it is extremely doubtful if the most



SUBMERGED PIPE LINE, PORTLAND, OREGON

accurate lathe work attainable would insure an absolutely tight joint under the conditions of the imposed test. During the experiments it was observed that the leakage was in every case confined almost entirely to the upper portion of the joint, the extreme lower portion being tight. This naturally suggested a secondary cause of leakage, which the most accurate workmanship would not overcome, viz., the extreme weight of the pipe. Each pipe weighs very nearly 5 tons. As the pipes lay in the trench, their weights were so distributed that a comparatively small portion of the entire weight was borne by the sockets. But in lifting the ends of the pipes 4 ft., the test imposed, the additional weights thrown on the sockets had the effect of slightly compressing the lead beneath, which, of course, produced more or less leakage in the upper portion of each joint.

Description of Pipe-Laying Device.—The apparatus used for depositing the pipes in the trench was designed by the authors. The method of using this device is clearly shown in the accompanying plates.

For laying in shallow water near each bank trestle bents were erected, one for each pipe, from which the pipes were suspended by long screws 1¼ in. in diameter, by means of which they were gradually lowered into position. (See engraving.)

For laying in deep water a cradle, constructed in the form of an inverted bowstring, was employed. One end was supported and pivoted between two barges, placed 10 ft. apart, while the other end was suspended between the barges at the rear by a long rod, which was always so adjusted as to permit the cradle merely to touch the bottom of the trench. (See engraving.)

The stresses in the cradle were carefully calculated, a factor of safety of 10 having been used in determining the dimensions of the various members. This may appear absurdly large at first thought, but after noting the severe treatment the cradle received during its progress across the river, not only from the imposed load, but from such extraneous influences as heavy swells from wind and passing steamboats, the authors are convinced that the factor used was none too large for the requirements.

All wooden members in the cradle consisted of full-length timbers, those forming the bottom chord being 100 ft. long. An auxiliary bottom chord, consisting of two 1¾ in. round rods, was added as a precaution against a possible weakening of the timbers, caused by bending them to the required radius.

The beam supporting the forward end of the cradle rested upon trunnions held in place by four 8 × 12 in. vertical posts, which served as guides. These posts were s cureley braced in three directions and were capped by 12 × 14 in. timbers, through which two rods, each 2 in. in diameter, passed to the trunnions below. This arrangement answered the purpose of a lift for the forward end of the cradle. The height of the frame was sufficient for a maximum elevation of 17 ft. This device made it possible to maintain a uniform angle of inclination for all depths of water.

Two 12 × 20 in. beams were laid side by side under the trunnions, the ends being supported on the centers of the barges. Whatever the position of the trunnions, blocking was inserted between them, while the rods were kept sufficiently slack to throw the weight directly on the beams.

The hanger from which the rear end of the cradle was suspended consisted of a 3½ in. round rod, with threads cut its entire length, hung from a 14 × 16 in. beam laid crosswise of the barges. The lower end of this rod was connected with a curved stirrup attached to the cradle.

The slide, on which the pipes were connected, and down which they moved into the trench, was composed of three 8 × 12 in. timbers, laid flat on 10 × 14 in. floor beams. The timbers were shod with flat rails, spiked every 2 ft. with countersunk rag spikes. Two lines of rails were laid on the center stringer and one on each outside stringer. The rails were used for the double purpose of reducing friction between contact surfaces, so that the pipes would slide easily, and of preventing excessive wear on the timbers. The slide was made to conform in cross-section to the outer circumference of the pipe joints.

To provide a continuous slide to the bottom of the trench an apron was attached to the cradle, being hinged at the first panel. The apron was shod with heavy plate iron. It answered the purpose admirably, even on the east side, where there were many bowlders.

Pipe Laying.—Pipe laying began on the east bank September 21. The first 13 pipes were connected and suspended from the trestle bents, previously referred to, just above the water line. Five pipes were connected and suspended from cross timbers on the pipe-laying barges directly over the center line of the cradle, which was suspended only a few feet below the water line. The barges were then moved into position at the end of the trestle, and the two sections were connected. This formed a continuous line of 17 pipes suspended over the water. The pipe were then gradually lowered by means of wrenches until the last five rested on the cradle, when the top lateral bracing was put in place. As soon as this was accomplished, the pipes suspended from the trestle bents were lowered simultaneously with the cradle to the bottom of the trench.

Laying from the cradle then began, and the work was prosecuted vigorously until shoal water was reached on the west bank. The pipes on the cradle were then suspended by long screws from timbers laid across the barges, the cradle was pulled out of the way, bents were erected and the pipes were suspended and lowered as on the east side.

The weight of the pipes on the cradle tended to push the pipe-laying barges ahead. Four 2 in. stern lines fastened to pipes already laid and extending to snubbing posts on the barges were used to prevent any forward movement while the joints were being made. When ready to move ahead, men stationed at the snubbing posts slowly and steadily slackened the lines, until the cradle moved the required distance. The lines were then made fast, and two more pipes were connected.

At times, owing to an ebbing tide or an abrupt change of grade in the bottom of the trench, the end of the cradle would sink into the sand and gravel sufficiently to arrest the movement of the barges, even though the lines were slack. This difficulty was overcome by a few turns of the wheel wrench which operated the rear suspension rod.

The barges were kept on the line by means of a float or raft made of piles attached to the up-stream barge and fitted between it and the row of piles described under the head of dredging.

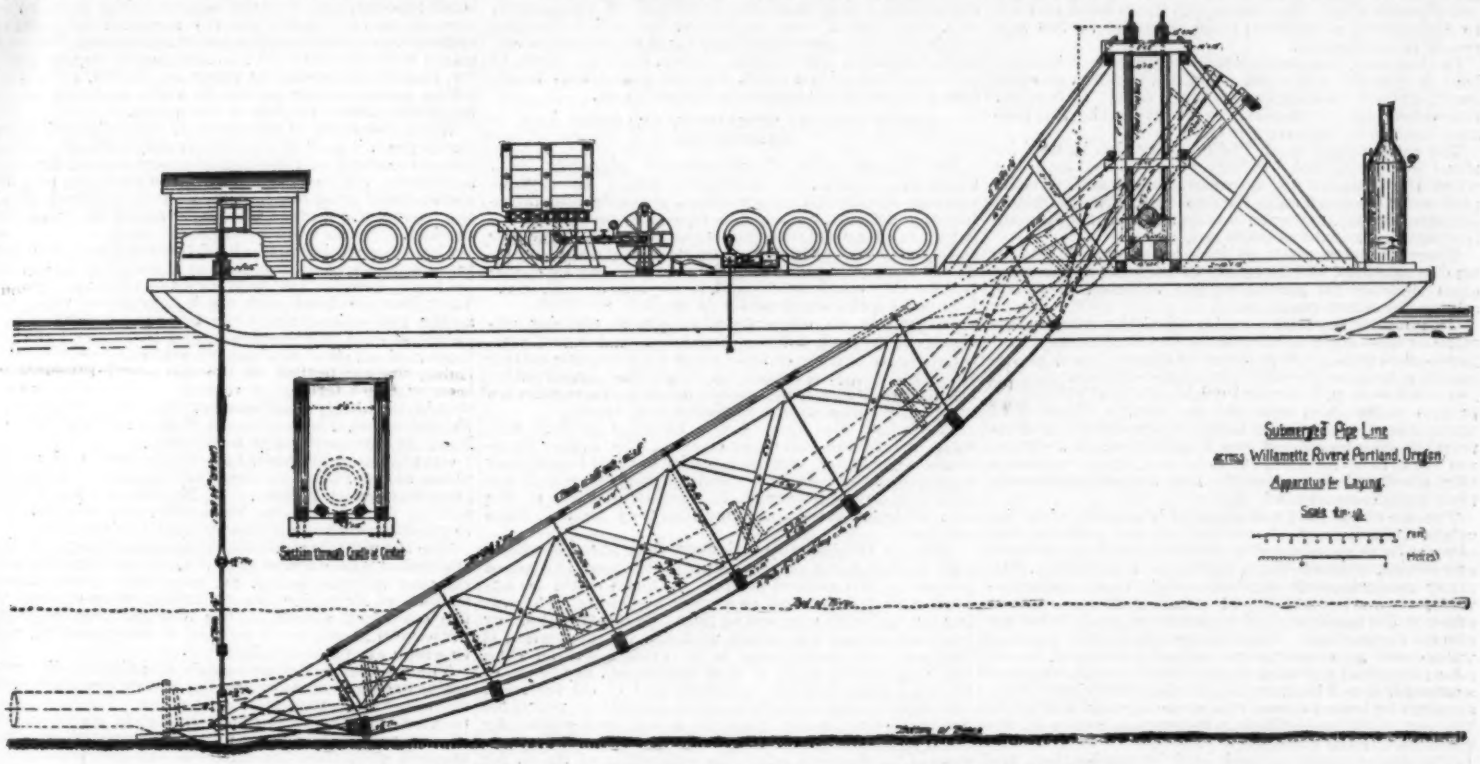
While laying pipe with the cradle 16 men were employed as follows: Foreman, 1; engineers, 2; testing the pipes and cleaning the ball ends, 6; melting lead, 1; pouring lead, calking and bolting, 6. Two members of the contracting firm were present most of the time the work was in progress. An expert diver was also employed continuously. With the exception of the diver, Mr. Ivar Johnson, of Chicago, none of the men had ever been employed on similar work. It required some time, therefore, to train them thoroughly before the work progressed smoothly. Two weeks of almost continuous rain also impeded the progress to some extent. Nevertheless, 100 pipes were laid in 20 days, an average of about 80 lin. ft. per day. This required 10 lead pourings and calkings for 40 in. joints and the bolting of five sleeves, each containing 38 bolts, to the flanged sockets of the pipes. Toward the close of the work, during exceptionally fine weather, from six to eight pipes were laid per day of 10 hours.

The line of pipes was tested by hydraulic pressure about every 200 ft. laid. When ready to test, the cast iron cap, referred to elsewhere, was bolted to the flange of the last pipe on the cradle. Water was admitted through the gate on the east bank. Pressure was then applied by a double acting steam pump, located on one of the barges. The pressure was continued until the derrick scow returned with a new load of pipes—usually the greater part of one day. During these tests the diver carefully inspected each joint and the pipes in general as they lay in the bottom of the trench. Leaks were easily located and were promptly calked. But little calking under water was necessary, however, the line being practically tight from first to last.

In making frequent tests the contractors had two objects in view: first, the final tightening or calking of the joints as they lay in position by pulling the ball ends tightly into the lead; second, the detection and stoppage of any serious leaks before the pipes became covered with sediment. That the "pulling" process was a success is fully proved by the following instance: When about 650 ft. of the pipe line had been laid, a pressure of nearly 250 lb. per square inch was applied for a few minutes; this had the effect of pulling the joint at the reducer, which connected the 32 in. line with the submerged line, an additional ¼ in. This joint had been started by previous tests, but in this instance the increased pressure gave the joint an extra pull, although the power was applied 650 ft. distant. The weight of the pipes laid when this test was made approximated 200 tons.

During the several tests it was impossible to determine the condition of the line with any degree of accuracy on account of the leaky condition of the gate. It was considered a good indication, however, that at the last test the pressure gage stood fully as well as at the first test, when every joint was visible and showed no sign of leakage. For this reason it is believed that the ball and socket joints are practically tight.

The line was subjected to 13 tests, including the final test prescribed in the specifications. This test was made after the line was connected with the 32 in. main on the west side, and consisted of a continuous pressure of 200 lb. per square inch for a period of 24 hours. According to the report of the engineer who conducted the test, the leakage was about ¾ gal. per minute. Although an attempt was made to determine the amount of leakage in the two gate chambers and at the pump connections, no accurate results were obtained. It cannot be assumed, therefore, that the submerged pipe line is responsible for any considerable portion of the reported leakage. The test also included 600 ft. of 32 in. pipe covered to a depth of from 10 to 15 ft.



SUBMERGED PIPE LINE, PORTLAND, OREGON—THE CRADLE.

Broken Pipes.—During the eleventh and twelfth tests a pipe was broken each time. In each case the break was doubtless caused by the wedging of the ball in its socket, the end pressure concentrating an enormous strain on a comparatively small portion of the socket. The first break occurred in the socket of the second joint from the end, while the second break occurred in the socket of the third joint from the end. In each instance the fracture extended spirally around the pipe for half its length. Four days were consumed in replacing each of the broken pipes. In the first case, it was necessary to drive piles and to raise several pipes already laid by means of long screws, in order to get the broken pipe above the surface of the water. The first pipe broken showed no indication of a flaw at the fracture; the fracture in the second pipe, however, betrayed very porous metal mixed with cinders. These were the only accidents connected with the work, and they could have been avoided easily by subjecting the pipes to a reasonable end pressure; 150 lb. per square inch or less would have answered every purpose.

In concluding this paper the authors desire to urge all the members who have had experience in laying submerged pipes to participate in the discussion, and thereby contribute the results of their experience to the profession.

(To be continued.)

APPLES AS BRAIN FOOD.—Apples are now recommended by many physicians as brain food, because they contain a quantity of phosphoric acid and are easily digested. When eaten at night some little time previous to retiring, they are said to excite the action of the liver and produce sleep.

[Continued from SUPPLEMENT, No. 1018, page 16287.]

RUSTLESS COATINGS FOR IRON AND STEEL.*

PAINTS: OF WHAT COMPOSED, HOW DESTROYED. CLASSIFICATION AS TRUE PIGMENTS AND INERT SUBSTANCES, ADULTERANTS, ETC.

By M. P. WOOD, New York City, Member of the Society.

RED Oxide of Lead, Pb_3O_4 (Minium).—This oxide is found native in various parts of the world, mixed with other ores of lead, and probably resulting from their oxidation. In some localities it accompanies cerusite or white lead ore.

When prepared for analysis, or when the commercial article is freed from the protoxide by digestion with a solution of acetate of lead, it contains 90·63 per cent. of lead and 9·37 per cent. oxygen, numbers agreeing exactly with the formula Pb_3O_4. It may be regarded either as a compound of the protoxide and peroxide of lead, $PbO.PbO_2$, or perhaps of the protoxide and sesquioxide, $PbO.Pb_2O_3$, analogous to the magnetic oxide of iron. Its specific gravity ranges from 8·6 to 8·94.

The commercial red oxide of lead is formed when the protoxide is kept at a low red heat for a considerable time in contact with the air; also, after the previous formation of hydrated protoxide and basic carbonate of lead, when lead shavings are strewn upon water, the vessel being loosely covered and set aside for some months, the formation of red lead taking place upon the surfaces of the lead exposed to the air.

It is largely manufactured in England in specially constructed furnaces, on the hearth of which the lead is melted and kept at a low red heat, and constantly stirred to allow oxidation to occur. The massicot so formed during the twenty-four hours of exposure to the heat is taken out, ground to a fine powder and washed, and again exposed in the same furnace for forty-eight hours to the same low red heat, until a sample taken out appears a dark red while hot and a bright red when cooling. The furnace is then closed and left to cool slowly, a condition most essential to the success of the operation.

In Germany, the conversion of the massicot into red lead is effected not upon a hearth, but in a peculiar barrel-shaped vessel open at both ends. It is sometimes necessary to repeat the operation by the German method to improve the color.

The carbonate of lead, $PbCO_3$, may also be used instead of the massicot for conversion into red lead; but when the temperature is properly regulated, another pigment is obtained, called orange lead. Red lead thus prepared, which, however, retains a little carbonic acid, is a pigment known as Paris red.

There are other methods for preparing red lead in small quantities, not necessary to describe, as the principal methods for furnishing the commercial article are by the above processes.

Commercial red lead contains all of the foreign metallic oxides—such as the oxides of silver, copper, and iron—with which the massicot or litharge used in preparing it is contaminated. It is also adulterated with red oxide of iron, boles, or brick dust; these substances remain undissolved when the red lead is digested in warm dilute nitric acid; boiling hydrochloric acid extracts the sesquioxide of iron from the residue. When red lead thus adulterated is ignited, there remains a mixture of yellow lead oxide and the red substances that have been added to it.

The use of red lead as a pigment is possibly of earlier origin than any of the oxides of iron, ochers, and other substances, natural or artificial, of which we have any record, unless it be asphaltum or lampblack. The many miscellaneous pigments that have come forward, been tried, and found wanting in some one or other of the qualities that constitute a good paint are almost numberless. There is no other color pigment whose use as a protective covering to wood, brick, stone, or metal has been so uniformly satisfactory and successful as red lead, and any failure to fulfill its mission can be traced directly to some agency foreign to the lead itself, used either in its preparation or in the methods of its application.

The characteristics of red lead, its application, and other qualities as a preservative coating for ferric and other surfaces have been so fully set forth in a previous paper (Montreal meeting, June, 1894, Transactions A. S. M. E., vol. xv, pp. 1013–1022) that it is unnecessary to repeat them here.

Mention is made (same volume, pp. 1027–1028) of the experiments of Sir William Thomson upon the effect of manganese dioxide ore (pyrolusite, MnO_2) as a pigment for the preservation of iron. Experiments still continue upon this substance, the merits of which are fully set forth in the claims of the English patent, No. 22,338, November 22, 1892. Several other substances also possess this magnetic oxide forming power upon the surface of ferric bodies—viz., scarlet lead chromate, the chlorates, and bichromate of potash—but none of them to the remarkable degree as pyrolusite, which can be produced in quantities to warrant its use as a pigment. It is strong enough enough in covering power and oxidizing qualities to warrant the admixture of other pigments that do not possess this magnetic oxide forming power, to allow for any change in the natural color of the manganese, which is a dark steel gray, sometimes bluish; other samples are an iron black. Its specific gravity is 4·819 to 4·97 when pure. Analysis of a number of samples of pyrolusite yield:

Red oxide of manganese	84·05 to 87·00
Oxygen	14·58 to 11·45
Sesquioxide of iron	1·30 to 0·40
Alumina	0·30 to 0·00
Baryta	0·67 to 1·20
Lime	Traces.
Silica	0·80 to 0·51
Water	5·80 to 1·12

The inert pigments in the manganese ore are so small in amount that they are not detrimental to the pigment. The sesquioxide of iron is readily removed if desired, but so far as the experience with the manganese pigment has gone, the iron has not been found to exert any unfavorable result. Like many other instances in nature, its oxidizing effect appears to be dominated by the oxide of manganese, which produces the first change on the surface of the iron in the form of the black or magnetic oxide, but does not take the second step, or change to the sesquioxide or scaling point.

The combination of red lead and manganese dioxide pigments appears to be favorable to each other. The manganese does not possess the setting power that red lead has to perfection; the presence of the manganese retards this setting power, and enables the combined paste to be kept for some thirty days without hardening, much as the presence of lampblack does with red lead, viz.:

One ounce of lampblack added to one pound of red lead, and mixed together dry before the oil is added, changes the color to a deep chocolate and prevents the red lead from taking its initial set with linseed oil as quickly as when mixed with oil alone.

This compound will remain mixed in a paste form for thirty days without hardening. If rapid drying of either the manganese or lampblack compounds is desired, japan drier can be mixed with the oil used to thin the paste before application with the brush.

This magnetic oxide forming power in the above named pigment is very obscure, and, being comparatively a recent discovery, has not received the attention that its importance demands. We are cognizant, however, of the fact that it exists, and the pigments that have this unknown power, in themselves alone or in combination with each other, may be properly classed as magnetic oxide paints in distinction from those called noncorrosive in the trade definition of that term. These magnetic oxide paints appear to be passive to the chemical changes which attend the drying of paint so far as oxidizing the organic matter in the liquid or oil after it has set or dried thoroughly.

The formation of magnetic oxide upon the surface of iron and steel by the action of manganese is of extensive application in the arts, where finished articles in iron or steel are plunged into a bath of melted niter containing a small amount of peroxide of manganese, and, after but a short exposure, the articles become oxidized with a permanent coating of a deep bronze color that sustains mechanical injury, such as blows or hard rubbing with a cloth, and are impervious to attack from ordinary atmospheric conditions.

CARBON PAINTS—ASPHALTUM, GRAPHITE AND LAMPBLACK.

The fourth class of preservative pigments, viz., asphaltum paint, in contradistinction to asphalt coatings as referred to heretofore, graphite and lampblack, constitute the carbon group, whose characteristics are as strongly marked as either of the three preceding ones and exceed them in respect of not being reduced to a lower plane of resistance to decay by oxidation (or slow combustion) and, it may also be said, of existence by quick combustion or fire.

Carbon, as an elementary substance, remains unchanged through all the centuries, and when combined to a greater or less extent with organic matter subject to decay, it asserts its rights as a preservative agent and insures a long life to any substance with which it is compounded or placed in contact.

The bricks that formed the hanging gardens and walls of Babylon and other cities of the plains thousands of years ago were bonded by natural bitumen or asphaltum, the thin layers and coatings of which are found to-day, unchanged, in vast quantities, in the soil, while the brick and stone that they bonded have perished.

There is trustworthy evidence that the Egyptians and earlier races of mankind understood the art of preparing this natural product so that it could be applied cold with a brush as a paint instead of as a coating applied with a trowel or mop. What the liquid or vehicle was that was mixed with the bitumen when it was used as a paint there is no evidence other than the assumption that it was linseed oil, as the use of linen for garments was universal, and of oil for food, the latter being made from olives and other vegetable products by placing them in a bag and subjecting them to pressure by piling stones upon it. The presence of the flaxseed led to the extraction of its oil for food; the siccative nature of the oil, being soon apparent, naturally paved the way for its use as a coating for domestic articles, and paint was born, long anterior to the time when the successors of Tubal-Cain were casting and beating into shape the sacred vessels for the Tabernacle upon the Plains of Zeredatha.

The wrappings of the mummies were prepared by saturating them with bitumen and some solvent, possibly poppy seed oil and natural naphtha from the wells and springs that abounded near the lakes where the bitumen was obtained ages ago, that were gray with the lapse of centuries when Moses stood before Pharaoh and pleaded for the freedom of his race.

The characteristics of asphaltum as a ferric coating are briefly given:

Asphalt or mineral pitch, specific gravity = 1 to 1·68, melts at 100° C. = 212° F. According to Boussingault (Am. Ch. Phys. [2] lxiv, 141), "is a mixture of two definite substances, viz., asphaltene, which is fixed and soluble in alcohol; and petrolene, which is oily and volatile. The greater part of the latter may be volatilized by distilling the asphalt with water."

It is the petrolene that gives the cementitious or bonding value to compositions into which it enters. Bermudez asphalt is about 2 to 3 per cent. purer than Trinidad. Samples of Bermudez analyze 97·22 per cent. of materials soluble in bisulphide of carbon. A large amount of these materials are also soluble in ether, showing that the bitumen contains large amounts of petrolene.

Petrolene in Bermudez = 81·63.
" " Trinidad = 80·01.

Egyptian asphalt is the purest of all the qualities of asphalt, but is not procurable at present in commercial quantities required for pavement or pigment coatings, but is used in the finer qualities of japanned or enameled wares.

Asphalt yields by dry distillation a yellow oil, consisting of hydrocarbons mixed with a small quantity of oxidized matter. It begins to boil at 90° C., but gradually rises to 250° C., giving oils of specific gravity during the boiling, viz.: 90° C. to 200° C., sp. gr. = 0·817 (at 15° C.); that which boils between 200° C. and 250° C., sp. gr. = 0·868 (at 15° C.); both portions giving by analysis 87·5 carbon, 11·6 hydrogen and 0·9 oxygen, which is nearly the composition of the oil of amber.

These asphalt oils, treated with sulphuric acid and then washed with potash and subject to dry distillation, yield a number of oils that are insoluble in water or strong nitric acid, and are but little affected by strong sulphuric acid, but are very soluble in alcohol or ether.

It is the writer's opinion that the future waterproof anti-corrosive paint will be made from these asphalt oils as the medium combining some of the carbon group of pigments, and that the drying qualities will be had by using some of the strong metallic salts, peroxide of manganese, umber, dioxide of manganese ore, red lead or litharge, all of which are available agents to aid in oxidizing the oil; and it is possible that some of the oxidizing or corrosive energy of the iron oxide group may be utilized to act as a drier, and, when this point has been reached, become a passive agent instead of a corrosive one to the paint and the metal which it covers.

There are a number of paints upon the market extensively advertised as asphaltum paints, or under other fanciful trademark names. The principal merit of some of these consists more in the name than the quality of the paint. If it is once considered that only about ten per cent. of asphaltum enters into the composition of the well known street pavements and that so little quantity as this amount, however it may govern the other constituents of the paving compound, has to be put in place or applied hot, and cannot be used or compounded in any other manner, it may be apparent that, notwithstanding the catchpenny name, really but little, if any, asphaltum of either high or low degree ever enters into the composition of any of these paints.

It is the writer's opinion, based upon an examination of many of these paints, that there is not as much as five per cent. of asphaltum in the composition of any brand of such paint upon the market. Even with this small amount, and with the best of boiled or raw linseed oil as the vehicle for the pigment, the paint is difficult to dry without the use of strong metallic salts mixed with the oil to aid its oxidizing or drying quality, and if a quick drying paint is wanted, these oxidizing materials are added in such amounts as to materially affect the life of the paint.

When the color of the paint is other than black or steely gray, it may be doubted if any asphalt will be found present under the closest analysis; and the red and brown colored samples will be found to rely almost wholly upon some oxide of iron as the base of the pigment, under whatever name it may be masked.

The characteristics of all of these colored or tinted trade paints appear to be almost identical with the iron oxide paints made and sold as such without disguise. They become hard and crack or scale off the same as the iron oxides, and after the second or third repainting even the manufacturers recommend the removal of all the old paint by burning or scraping before the application of the new coat, a proceeding that with a thoroughly reliable and durable paint should be wholly unnecessary. (See vol. xvi, paper No. 626, p. 399, Transactions A. S. M. E. United States Navy Department paint tests, 1885.)

Graphite as a pigment, both the foliated and amorphous brands, has been described in a previous paper (Montreal meeting, June, 1894, No. 598, vol. xv, Transactions A. S. M. E., pp. 1033—1072), but some additional information is available upon their merits.

The Detroit Graphite Manufacturing Company, the analysis of whose brand of L. S. G. amorphous graphite pigment is given in vol. xv, page 1072, present some samples of its application to boiler tubes exposed to the combined action of fire and hot water under pressure that will be of interest to the members, and to which attention is called.

The resistance of these brands of paint to the corrosive action of acids or alkalies is very remarkable, as the following severe tests will show. Pieces of iron painted with them have been dipped in muriatic, sulphuric, and oxalic acids, and then allowed to dry with the acid upon them for nineteen days, without showing a trace of any damage to the paint. The longest time that other paints withstood these conditions was twenty-four hours, and then they were rapidly and entirely destroyed. These paints have been immersed in ammonia and sal-soda for nineteen days, in coal oil for several weeks, in strong brine for six years, without showing injury. Pieces of iron have been coated with L. S. G. and submitted to twenty-four hour tests in boiling alcohol, boiling beer, boiling brine, boiling sugar and water, without the paint showing any injury. Red lead paint exposed to boiling alcohol stood fifteen minutes; in boiling beer thirty minutes; in boiling brine twenty-five minutes; in boiling sugar and water fifteen minutes. L. S. G. paints immersed in cold soft soap stood twenty-four hours without injury, while other paints stood for one hour only. All of the above tests are extremely severe conditions, and can hardly arise in practical use, except under exceptional cases.

Smokestacks painted with "superior" graphite paint have been heated to redness without blistering. Sheet tin coated with these paints can be twisted and bent in all directions wfthout scaling or cracking the paint. Some samples of the boiler tubes coated with these paints, and mentioned in a former paper (Transactions A. S. M. E., vol. xv, p. 1033), showing the power to resist the formation of scale, have now been in use for some two years and are submitted for inspection.

That these paints can be furnished in colors other than the dingy or steel gray color natural to the graphite pigment is another recommendation.

Lampblack, when ground in either raw or kettle boiled linseed oil, forms a most effective protective coating against corrosion of ferric surfaces, as well as decay in wooden or mineral bodies. The lettering of sign boards is a familiar example of the merits of a simple thin coat of this paint to protect all that it covers more effectually than any other known pigment. The life of any paint can be almost foretold from the fineness that it is ground to when incorporated with the oil. Lampblack, from its method of manufacture as a deposit from the products of im-

* Presented at the Detroit meeting (June, 1895) of the American Society of Mechanical Engineers, and forming part of Volume XVI of the Transactions.

perfect combustion, is primarily in a condition to be easily prepared for a pigment. White lead makes a good paint when mixed with one-eighth of its weight of oil. Ivory black requires its own weight in oil, and lampblack much more. All dark color pigments, being but slightly basic in their nature, require more oil in their preparation than light colors. It is noticed in picture and portrait paintings that the cracks in the paint are far more numerous in the dark colors (not blacks) than in the white or light colors.

INERT PIGMENTS.

The different substances known in the market as inert pigments, whose use is to a more or less extent admissible, are, viz.: barytes (heavy spar); whiting (prepared chalk); gypsum (sulphate of lime, American terra alba); kaolin (pipe clay); ground silica; ground talc (steatite or soapstone); ground feldspar (decomposed mica, granite, gneiss, and most kinds of basalt).

Feldspar is inclined to decompose readily when exposed to the weather. Many of the clay beds now used to make fire brick are simply broken down and decomposed feldspars. Its use in a pigment or in the composition of a pigment of any material that is to be durable or unchanged on exposure to the weather is to be avoided.

Talc does not grind well and is inclined to cause a paint to peel.

Kaolin grinds greasy. In many cases both talc and kaolin can be added with manifest advantage to pigments that are of a granular nature.

Silica grinds hard, but its use is less objectionable than some of the other before named materials, and, as a pigment, to be durable, must be brought to a fine state of subdivision; its use otherwise is to be avoided.

Barytes, from its great weight, is but little used, though its qualities otherwise are beneficial in a pigment.

Whiting, when used as a pigment, is liable to a chemical reaction between the oil and itself which may possibly result in the formation of a lime soap, which is not at all durable. Putty, however (which is a mixture of oil and whiting), is a very durable body, and withstands exposure to atmospheric effects and water remarkably well.

Sulphate of lime (gypsum), all things considered, is possibly the best of the inert substances used as component parts of pigments. It is a hydrated material that has as a part of its composition two molecules of water. The heat caused by the friction of grinding drives off a portion of this chemically combined water, and if perchance this water is taken up again before the paint is spread, there is a tendency on the part of the paint to "liver," a phenomenon familiar to all painters; but the causes that contribute to this change have not been clearly defined, and there is still much mystery in the subject to be unraveled. Sulphate of lime is of great durability; it is chemically inactive as a pigment; it has a low specific gravity, and can be easily and minutely ground and incorporated with whatever pigment it is desired to mix with it and the liquid. It does not "set" nor settle rapidly in the paint bucket, and its use has no specially undesirable features.

Protection from corrosion is a term about as varied in its definition as the number of persons, whether master painters or engineers, who use it. In general, it may be said to mean that some compound, either a paint or a coating, has been applied to a metallic object to prevent its decay from natural causes incident to its location or intended use, or both.

The progress that the mechanical arts make in the life of each generation of men in a great measure limits the life of most engineering structures, regardless of the failure of the said constructions from natural causes or accident, even if they were left as they came from the workman's hands without a coat of paint.

There are but few of the important railway bridges and viaducts of iron and steel that have been erected during the past thirty years, either as constructions for new lines of railway or to replace the wooden structures that formerly were the order of the day, that will not be pulled down (if they do not fall down, as in too many instances is the case) ere they are forty years of age—a change rendered necessary by the use of heavier engines and trains at higher speeds, to say nothing of the better constructive methods and materials in them; and he will be rash, indeed, who will declare that the next fifty years will not see as many radical changes in these structures as has taken place in the past.

The thousands of iron and steel vessels that compose the world's merchant and naval marine have been reconstructed in design every ten years since the keel of the first iron vessel was laid, and whether as the ocean greyhound that with peaceful intent races against time on her ocean trips, or the formidable battleship or armored cruiser, after but a few years of active life they all join the endless procession toward the marine junk shop of obsolete patterns; while corrosion, speeded on its way by the combined action due to sea air, sulphur and bilge water, high temperatures, marine growths, and the inaccessible portions of many parts of the ship, holds high carnival, and, as it were, laughs at the puny efforts of man to check its career by dabs with a paint brush.

Well indeed may the engineer inquire, "How shall we protect the ship?" and, from the complex nature of the question and the unsatisfactory nature of many past experiments, cease to wonder at the practice of some engineers, civil as well as marine, in coating the structure or vessel with almost anything in the way of paint, regardless of quality, composition, or merit, so that it covers the stains, pleases the eye, costs little, dries quickly, and makes a shadowed semblance of protection. Why spend much money or worry over a thing that is on the way to retirement as a back number almost before it leaves the builder's hands, and whose life will, no doubt, not exceed my own?

If it is a ship or other marine construction, furnish something that will permit it to be painted one day, got out of the dockyard the next day, and that will keep the marine growth and fouling down, and the expense of docking, scraping, and painting it again next year will be gladly borne.

If it is a railway superstructure, it must be painted and dry ere the workmen's hammers have ceased to ring upon it. If it is a railway freight car, why, there are built, repaired, and repainted, at many railway shops, one hundred and fifty cars per day, each one requiring some thirty-five feet of space upon the paint shop track; and if these cars are to receive two coats of paint, and be required to wait from three to four days for each of them to dry, it means some eight to ten miles of paint shop, shed, or side track room, and railway companies will make no such provisions, even if at the end of ten years it would prove not only better but cheaper than the customary rush methods or practice of one day for each coat of paint, including spreading and drying, regardless of any atmospheric conditions that have so much influence over the latter.

Prominent master painters have remarked, when some specially prepared and well-tested brand of paint has been called to their attention for its protective or lasting qualities: "We do not believe in any paint that lasts fifteen years or more; it is not good for the trade, and if the use of such paint bids fair to become general, we want to get out of the paint business."

There are many special paints in the market, some of them of great merit for the particular purpose for which they are compounded; but not being generally anti-corrosive, they cannot be detailed without requiring too much space in this paper, and their record is only of interest as showing the efforts made to prevent corrosion. Samples of some of these special coatings are presented for examination.

The liquid medium that enters into the composition of all paints, anti corrosive or otherwise, is of importance enough to warrant the preparation of a paper upon that subject alone. Its consideration is, therefore, postponed to the fourth and closing paper of the series of articles on rustless coatings.

THE DEVELOPMENT OF THE EXPERIMENTAL STUDY OF HEAT ENGINES.*

IT was Mr. Forrest's intention that the annual lecture bearing his name should illustrate the dependence of the engineer in his practical professional work on the mathematical and physical sciences. It therefore naturally takes the form of a review of some branch of engineering with special reference to the scientific principles which have been factors in its advancement.

Twenty years ago, Lord Armstrong stated that of all the coal raised in this country about one-third was used for household purposes, one-third for generating steam, and one-third for iron making and manufacturing processes. He remarked that in the first two divisions the waste of fuel was shameful, and that without carrying economy to extreme limits, all the effects now realized from the use of coal could be obtained by an expenditure of half the quantity. The improvement of the steam engine is mainly due to an incessant attempt to diminish the waste of fuel.

TESTS OF STEAM ENGINES IN CORNWALL.

Steam engineers have been face to face with the problem of economy for more than a century. Coal was excessively dear in Cornwall, and as the mines were deepened and more power was required, the cost of working increased ruinously. By reducing fuel cost, Watt saved the mining industry from extinction, and he adopted the plan of taking in payment for his engines a sum reckoned equivalent to one-third of the fuel saved. By agreement with the miners, tests were made, and the standard duty of a Newcomen engine was fixed at 7,037,000 foot lb. per bushel. Regular duty determinations were made for all Watt's engines. Generally they gave a duty of 20,000,000. When Watt's connection with Cornwall ceased, in 1800, the duty determinations were neglected, and the engines deteriorated.

Then Captain Joel Lean, who reorganized the machinery at one of the mines, and effected great economies, started again the system of duty trials. He and his sons carried on the work for many years, and published reports of the results of the trials. Of these reports Dr. Pole says: "The publication produced an extraordinary effect in improving the duty of the engines. Engineers were stimulated to emulation among themselves. The practice of reporting is thought to have been attended with more benefit to the county than any other single event excepting only the invention of the steam engine itself."

I shall show later that the creation of a new and more scientific system of testing by Hirn and his colleagues in Alsace, in 1855, was the starting point of a similar process of improvement. Quite lately there has been a revival of careful and independent engine testing and of the publication of the results, and records have been established which would have been thought impossible ten years ago.

The peculiar character of the load against which the Cornish engine worked, the lifting of a heavy mass of pump rods, contributed to force the use of expansive working. To work without shock, a large initial and gradually diminishing effort was necessary. The extraordinary economy obtained was due probably in part to the special action of the steam, the Cornish engine being virtually a compound engine, and the admission surface being protected from cooling to the condenser; partly to the great effectiveness of a steam jacket in an engine which worked slowly and with pauses at the end of the stroke, partly to the small clearance and separate admission and exhaust valves. The lesson engineers should have learned from Cornish experience was that in restricted conditions high ratios of expansion were economical. In this case, as in others, later engineers generalized too crudely, and concluded that expansive working was always economical. A new scientific investigation was required to correct the error.

EXPERIMENTS ON BOILERS.

To generate steam power economically the boiler must be efficient, and the engine must be efficient, and the conditions of efficiency of boiler and engine are completely independent. Hence the early method of Watt, in which attention was paid only to fuel used and water pumped, has been replaced by a method of independent boiler and engine testing. The boiler uses coal and generates steam; the engine uses steam and generates power. The economy of the boiler is reckoned on the fuel; that of the engine on the steam.

Different coals, at any rate the better kinds of coal, do not differ much in absolute calorific value. Used in boiler furnaces, they differ more, partly from differences of mechanical aggregation, but chiefly because the more bituminous coals require a larger air supply for tolerably smokeless combustion than those which consist chiefly of fixed carbon. The greater excess of air involves greater chimney waste. It is to test the commercial calorific value that Professor Schroter has established in Munich a heat laboratory where fuels can be tested on a large scale and under ordinary practical conditions of combustion. The arrangements permit the determination of the exact conditions most suitable for each fuel.

An enormous number of boiler trials have been carrien out, but most of them are mere individual tests of very little scientific value. Engineers have been too much under the impression that the evaporation depended chiefly on the type or proportions of the boiler, or the arrangement of the heating surface. But there are no obscure or complicated actions concerned in generating steam. Boilers of all types give nearly the same results, provided only proper conditions of combustion are secured. They may differ in cost, in durability, in convenience, but in efficiency they differ less than I think is commonly assumed. The following table shows that boilers of extremely different types, with very different proportions of heating surface and very different rates of combustion, and even with different coals, have all reached evaporations of from 11 to 13 lb. of water from and at 212° per pound of coal:

BOILER TRIALS.

Type.	Ratio of grate to heating surface.	Coal per sq. ft. of grate per hour.	Evaporation from and at 212° per lb. of coal.	Coal.
Cornish.....	—	7·3	11·9	Welsh
Lancashire. ..	1 : 30	22·9	11·2	Lancashire
Galloway	1 : 24	8·5	11·6	Anthracite
Portable	1 : 69	12·8	11·8	Welsh
Tubular	1 : 46	10·8	11·9	Anthracite
Babcock.....	1 : 38	8·9	11·8	Anthracite
Marine	1 : 34	22·4	12·9	Welsh
Marine	1 : 50	25·5	12·5	Lancashire
Thornycroft...	1 : 70	7·7	13·4	Welsh
Thornycroft ..	1 : 61	18·6	12·5	Welsh

MULHOUSE TRIALS OF 1859.

The earliest boiler trials carried out in a completely satisfactory way were those made by the Societe Industrielle, of Mulhouse, in 1859. The society offered a prize to the maker of any boiler which would evaporate 1,800 lb. per hour, at 75 lb. per square inch pressure, and which would evaporate 9·1 lb. of water, from and at 212° per lb. of Alsatian coal of not very good quality. With the coal used in these trials, 190 cubic feet of air per pound of coal are chemically necessary for complete combustion. It was found that the reduction of the air supply almost to this limit, and to a point at which there was definitely incomplete combustion, reduced the chimney waste and increased the efficiency of the boiler. In two special trials, each of a week's duration, the evaporation was 9 lb. with 331 cubic feet of air per lb. and 9·53 or 6 per cent. more with 247 cubic feet.

The determination of the air supply to a boiler is not altogether an easy operation. An anemometer was used in Alsace, and in suitable conditions it will give approximately accurate results. In recent trials chemical analyses of samples of the furnace gases have been made, and the amount of air supplied calculated from the percentage of CO_2. This method is accurate in principle, but the samples analyzed are a very minute fraction of the total chimney discharge, and the samples may not be average samples. In some trials in which this method has been used, there are discrepancies in the ratio of the chimney loss and the undetermined loss, chiefly due to radiation, difficult to understand. Neither anemometer nor chemical analysis is suited to serve as a means of regulating the air supply in the ordinary working of a boiler. What is wanted is an instrument as easily read as a pressure gage, and giving continuous indications.

THE DASYMETER.

The dasymeter, invented by Messrs. Siegert & Durr, of Munich, is a fine balance in an inclosed case through which a current of the furnace gases is drawn. At one end of the balance is a glass globe of large displacement, at the other a brass weight. Any change of density of the medium in the chamber disturbs the balance. A finger on the balance moving over a graduated scale gives the amount of the alteration of density. An air injector draws the furnace gas from the flues, and it is filtered before entering the balance case. An ingenious mercurial compensator counterbalances any effect due to change of temperature or barometric pressure.

The dasymeter is usually combined with a draught gage, and an air thermometer or pyrometer in the flue is required if the amount of waste heat is to be calculated. The dasymeter requires, initially, exceedingly delicate adjustment, and its indications must be checked from time to time by a Bunte's burette. It is set to read zero with pure air, and then any increase of density due to CO_2 is read as a percentage on the scale. When in adjustment, it is as easy to read the percentage of CO_2 in the furnace gases as to read the pressure on a pressure gage. When the dasymeter is fitted to a boiler, the stoker has directions to adjust the supply of air so that the furnace gases have about 12 per cent. of CO_2. With practice he learns what alterations of the damper or fire door or thickness of fuel on the grate are necessary, or whether an alteration of grate area is desirable. After a little time the percentage of CO_2 can be kept very constant.

ISHERWOOD'S EXPERIMENTS ON MARINE ENGINES.

About the year 1860, Mr. Isherwood, Chief Engineer of the United States Navy, began a series of systematic tests of engines and boilers on a very large scale, and with resources only available in a government establishment. The trials were made with skill and determination, and the substantial accuracy of the re-

* Abstract of the "James Forrest" lecture, delivered at the Institution of Civil Engineers, May 2, by Professor W. C. Unwin, F.R.S.—Nature.

sults, startling as they were, has never been questioned.

All Isherwood's trials of large marine engines showed that when expansion was extended beyond exceedingly small limits, it caused not an economy, but a waste. In his second volume he sums up his results as proving that when cut-off is earlier than 0·6, or perhaps even 0·7 of the stroke, the consumption of steam reckoned on the work done is increased. Curiously enough, this led him to attack the compound engine. From the quantities in the table of experiments, he says, "It will be seen how useless in point of economic gain is the preposterous arrangement of steam engine known as the double cylinder, Wolff, or Hornblower engine. . . . Opposed to these facts, the declarations of interested patentees and engine builders must be classed in value with those set forth by quacks in advertisements of their nostrums." This is from a paper dated 1865, and it is curious, because Isherwood generally saw clearly enough the danger of drawing sweeping conclusions from narrow experimental premises.

The proper lesson from Isherwood's results was merely that certain conditions must be observed to secure economy in expansive working. Unfortunately, more generally the conclusion was drawn that the Cornish results were not to be trusted, and that expansion was not economical, and Isherwood's own language lent authority to the least accurate view of his results. To obtain greater insight into the true action in the cylinder, and to find a reconciliation of the Cornish and American tests, experiments of a much more refined character were wanted and insight due to wider scientific knowledge.

THE PHYSICAL PROPERTIES OF STEAM—REGNAULT.

No useful progress could be made with a theory of the steam engine, no accurate deduction even could be made of the results of engine tests, without exact determinations of the relations of pressure, temperature, volume, latent heat and liquid heat of steam. It was fortunate, therefore, that about 1840 M. Regnault obtained the means from the French government to make a series of researches on the physical properties of steam with splendid instrumental appliances. He wisely carried out his determinations over a very wide range of conditions, and spared no labor or trouble in attaining accuracy. Regnault's results were of the greatest importance as a foundation for accurate study of the steam engine.

THE FOUNDATION OF THERMO-DYNAMICS—CARNOT AND JOULE.

The next important step was the discovery of the equivalence of heat and work. Joule's investigations began with an attempt to improve Sturgeon's magnetic engine. He was so led to consider motive power problems from the engineer's standpoint as a question of duty, or of something obtained for something expended. He ascertained the amount of electric current produced by the chemical combustion of a given amount of zinc, and comparing his results with those obtained in good steam engines, he concluded that, making the largest allowance for possible imperfections of his magneto engine, it was never likely to be a rival in economy to the steam engine. That was a negative but a useful result. It closed one direction of useless endeavor only too likely to attract the inventor.

One of the effects of electric action which Joule noticed was the heating of his conductors, and it was to the measurement of this heating effect he next addressed himself. The heat developed in the conductor by the electric action due to elements combining in the galvanic cell was found to be identical with that which would be generated by the direct combustion of the same elements. Finally, he came to consider the relation between the mechanical work expended in driving a magneto-electric machine and the heat developed in the external circuit of the machine. He concluded that for 838 foot lb. expended a pound degree of heat was generated. Later experiments corrected this value, but the discovery of the equivalence of heat and work was made.

As early as 1824, twenty years before Joule's discovery, Sadi Carnot, in a remarkable pamphlet on the "Motive Power of Heat," demonstrated the fundamental principle that the amount of work obtainable from any given quantity of heat cannot exceed a quantity proportional to the fall of temperature. Unfortunately adopting, though with hesitation, the view held in his time that heat is material and indestructible as heat, he coupled with his true principle the false corollary that all the heat entering an engine is discharged in the condenser. Joule, in 1845, found this principle of Carnot and looking to the corollary as essential, supposed the principle itself to be false. He failed to perceive that Carnot's principle was the essential supplement to his own discovery, and that it showed why the apparent efficiency of the steam engine is so low. It took six years before Joule's and Carnot's principles were reconciled, and for three of them even Lord Kelvin refused to accept Joule's discovery, because it apparently conflicted with the principle of Carnot.

THE FOUNDERS OF THE RATIONAL THEORY—RANKINE, CLAUSIUS, ZEUNER.

The impetus given to the study of thermodynamics by the discovery of Joule, and the perception of the fundamental importance of Carnot's theorem, was enormous. Heat problems could now be brought out of the region of mere empirical solutions, and treated from the rational standpoint of an exact science, and the steam engine, as the most important example of heat transformation, attracted at once the attention of scientific men of commanding intellectual ability. In a very few years Rankine and Clausius had built up a strictly rational mathematical theory of the steam engine, and, a little later, Zeuner carried further the analysis of some of the more subordinate details. The theory, with one exception, to be referred to presently, took account of all the actual conditions under which steam is used, and furnished exact rules for the relation of steam expended and work done for all arrangements of the actual steam engine practically adopted.

It was just at this time that the experiments of Isherwood were published, and a comparison of experimental results and theoretical calculations showed directly a very large discrepancy. The steam consumption in some trials was 30, 40 or 50 per cent. more than it should have been in the assigned conditions of working according to the rational theory. Some action of quite governing importance had obviously been neglected in the theoretical analysis.

THE EXPERIMENTAL THEORY—HIRN AND THE ALSATIAN SCHOOL.

A year or two before Isherwood began his experiments, an Alsatian engineer, M. Hirn, had discovered and measured cylinder condensation.

Joule's discovery attracted Hirn's attention, and he set to work in 1854 to verify, by an exact engine test, whether the difference between the heat received by an engine and discarded in the condenser was the equivalent of the work done. His two most important memoirs relating to the steam engine are a memoir on the utility of steam jackets, in 1855–6, and another on the use of superheated steam in 1857. In these researches he devised a method of accurate engine tests, involving the measurement of all the quantities of heat received by or rejected from the engine, which, with hardly any change at all, is the method of accurate engine testing adopted ever since. Under his influence and direction, engine tests were carried out in Alsace for many years, and the results exactly analyzed. It may be recalled that the admirable series of engine tests, the first tests in which the heat quantities were accurately measured in this country, which were made by Mr. Mair Rumley, and described in three papers on "Independent Engine Tests" in the Proceedings of this society in 1882, 1885, and 1886, were trials carried out strictly in accordance with Hirn's methods.

As with Lord Kelvin, so with Hirn. It was the recognition of an apparent conflict of Joule's discovery with Carnot's law which first attracted his attention. It was the attempt to determine whether part of the heat supplied to an engine disappeared as work which determined the form of his trials. His experiments of 1854 showed that "heat in a steam motor is not only dispersed, but actually disappears, and the power obtained is exactly proportional to the heat which disappears as heat to reappear as motive power." Some rather later and more careful experiments enabled him to verify Joule's equivalent by the actual results of a large engine test to an accuracy of about one per cent.

The discovery of initial condensation, and the proof of the powerful action of a small amount of heat transmitted from the jacket, both pointed to the conductivity of the cylinder wall as the cause of the large waste of steam which the constructors of the rational theory had neglected. The cylinder is cooled during expansion, and still more during exhaust by an action analogous to internal radiation to the condenser. Before any work can be done in the next stroke, the wall has to be reheated by condensing fresh steam. The extreme facility with which steam yields or abstracts heat by condensing and evaporating accounted for the rapidity of the action. The magnitude of the condensation increases with the range of temperature to which the cylinder wall is subjected. It is larger in condensing than in non-condensing engines, and larger with high ratios of expansion.

Some time ago I ventured to say that there was no trustworthy engine test which showed that the consumption of steam with a jacket is greater than without the jacket. I believe that is still true, but undoubtedly the economy due to the jacket varies in different cases from 30 per cent. to very nearly zero. Roughly, the jacket is more useful with small engines than with large; with slow engines than with fast engines; but all this amounts to little more than saying that the jacket is most useful in those cases where the initial condensation is largest. Just in proportion as the engine, whatever its type, is of the highest class and most scientific design, the jacket is less useful.

The jacket reduces, but it does not prevent initial condensation. Hirn looked for some more powerful way of heating the cylinder wall without causing condensation; he found it in superheating. He constructed, in 1855, a superheating apparatus in the flues of the boiler at Logelbach, which still exists. The experiments with superheated steam were carried out between 1855 and 1856, and showed clearly the effectiveness of the method in reducing condensation. Superheating came largely into use in the years 1860–70 in this country in marine engineering, the practice having been introduced here by John Penn. In every case in which it was used an economy of coal was realized. Generally the economy amounted to from 15 per cent. to 20 per cent. It was ascertained that this was due strictly to economy of steam, and not to the utilization in the boiler of heat previously wasted. But the use of superheated steam in this country was gradually abandoned, partly no doubt from some practical difficulties, but chiefly, I believe, because practical engineers had no clear idea why superheating should produce so large an economy, and they were not indisposed to abandon a complication the action of which they could not satisfactorily explain to themselves.

No possible improvement of the steam engine, of which we have any knowledge at this moment, offers anything like so great a chance of important economy as the reintroduction of superheating, and especially of superheating to at least 100° or more above the saturation temperature of the steam. I obtained in Alsace on a very good 500 H. P. compound mill engine with jackets, and every appliance for economical working, an economy of 15 per cent. Mr. Mair Rumley has fitted a superheater to a Babcock boiler supplying a triple engine, and has obtained an economy of 10 per cent. In both cases the economy is economy of steam, and therefore is not due to any increase of boiler surface or increase of efficiency in generating the steam. Lately Prof. Schroter, of Munich, has been experimenting with a small special compound condensing engine of only 60 I. H. P., running at the moderate piston speed of 380 feet per minute, and with the not excessive boiler pressure of 165 pounds per square inch. The H. P. cylinder is not jacketed. The L. P. is jacketed with receiver steam. In this case, in a tube superheater of a rather special construction in the uptake of the boiler, the steam is superheated to 670° F., or nearly 300° above the saturation temperature corresponding to the pressure. In two trials of six and eight hours' duration, periods quite long enough for accurate determination of results with so accomplished an observer as Prof. Schroter, the consumption of steam was only 10·2 pounds per I. H. P. hour, and the consumption of German coal of moderate quality only 1¼ pounds per I. H. P. hour. The steam consumption is the lowest on record for any engine of any type or size, and is very remarkable for so small an engine.

CONFLICT OF THE RATIONAL AND EXPERIMENTAL THEORIES—ZEUNER, HIRN, AND HALLANER.

On the appearance of Isherwood's researches in 1863, the discrepancy between the rational theory and the results of experiments was recognized by Rankine and others. But the conditions of cylinder condensation are so complex, that for a long time the more theoretical writers practically ignored both Hirn's and Isherwood's results. Zeuner, perhaps, had pushed the rational theory to the furthest limit of detail, and with the greatest insight into practical conditions. But it was not till 1881 that he began to explicitly admit the largeness and importance of the condensing action in the cylinder. Zeuner then was disposed to attribute initial condensation to the presence of a permanent and not inconsiderable mass of water in the clearance space of the engine. No doubt it is simpler analytically to deal with the thermal changes of the steam plus a given mass of water than with the thermal changes of steam, water, and a varying area of solid cylinder wall. In opening a discussion with Hirn in 1881, Zeuner wrote that if the presence of water in the clearance space was conceded, the Alsatian calculations would be greatly shaken, and "the enormous influence which they attributed to the cylinder wall would in future be attributed in part, perhaps chiefly, to the water in the clearance space." He thought it conceivable that in certain cases the whole of the initial condensation was due to water in the clearance space. There thus arose a rather angry controversy, which has been summed up in the question, "Is it water or iron?" I do not know that this controversy has been as yet completely decided, or that perhaps an absolute decision is possible. I cannot help thinking that Hirn, with the clearness of view due to his experimental work, had on the whole the best of the controversy, and I do not know that anything better or more instructive can be said than the words in which he finally summed up his position. "We recognize," he said, "that the interpretation of the Alsatians differs from that of M. Zeuner, not at all in that it denies the possible presence of water in the cylinder (we are not so hydrophobic), but in that it admits that the water, varying in quantity, is presented only temporarily, is carried away and renewed stroke by stroke, and acts chiefly as the medium between the steam and the cylinder wall. In the Alsatian explanation the action of the water raises the thermal action of the sides. In Prof. Zeuner's view, the water is permanently present and acts independently of the cylinder sides."

RECENT SYSTEMATIC EXPERIMENTS—WILLANS.

It has been quite impossible in this lecture to do more than select one or two of the most important of the experimental investigations during the last fifty years. But I should not like to omit all reference to the two series of experiments of the late Mr. P. W. Willans. Mr. Willans' work is no doubt well known to all steam engineers, and needs no detailed description. However purely practical the object Mr. Willans had in view, his experiments were made in the true spirit of scientific research. No trouble was too much to secure accuracy to the last decimal, no possible cause of error was so trivial that its investigation was reckoned unnecessary. A few experimenters, Isherwood, Gately and Kletsch and others, had made experiments on a methodical system, varying a single factor at a time. Willans carried out the method of experiments in series on a scale which, till he proved that it could be done, no one would have supposed possible. There is a series of non condensing and a series of condensing trials; in each there are trials of simple, compound and triple engines; and for each of these, again, trials with initial pressure varied, with expansion varied, and with speed varied. The results, tabulated in the clearest way, form a quarry of scientific data, but at present, in the main, an unworked quarry. Perhaps that statement will seem surprising, and, of course, I am expressing only my own view, for which I claim no infallibility. What Mr. Willans might have done had he been spared, it is impossible to say. He had the most active mind and the widest experience devoted, perhaps, at any time to the study of steam problems.

Let me protest as strongly as possible, again with the reservation that I am stating my personal view, against the tendency to suppose that the great work of Willans can be summed up in a so-called Willans' law, or that that law, handy as it may be for practical steam engineers, is more than a quite subordinate part of Willans' work. The Willans' law is nothing more than the empirical descriptive statement that the relation of total steam consumption and indicated or effective horse power can be very approximately expressed by a linear equation, for the case of an unjacketed engine working with a fixed cut-off. Further, nothing is done in Willans' papers to fix what is the linear equation for any given engine. So far as those papers go, and until some kind of theory taking account of initial condensation is discovered, we can only find the relation of steam consumption and horse power for any given engine by making two accurate trials of the engine itself. Willans' law leaves us in regard to any given engine in the same position as an astronomer with a new comet. When the comet has been observed for a sufficient period, and some of its positions fixed, a probable orbit can be calculated. The straight line law leaves the steam consumption of a new engine as unknown as the elliptic law the orbit of a new comet.

Willans himself says nothing whatever as to any possible rational basis for the Wilians' law. He put it forward purely as the result of plotting his experiments. Later, Captain Sankey showed that the total steam consumption of an engine working adiabatically with fixed ratio of expansion would also follow nearly, but not exactly, a straight line law, if all clearance losses, radiation and exhaust waste and back pressure loss were neglected.

If we assume isothermal expansion (and really, so far as the area of the diagram is concerned, it matters little what law of expansion is assumed), it is easy to find a formula for the total steam consumption of an

engine working without clearance loss or exhaust waste. I have found such a formula, and plotted the results both for a condensing and a non-condensing engine in the diagram. It is found that the lines plotted are not exactly, but very nearly, straight lines. That carries us a certain way, but it is an enormous jump to assume without examination that the steam wastes in the engine, amounting to from 20 to 50 per cent. of the steam used, and arising from causes of the most complex kind, depending on the volume of the clearance, the action of the cylinder wall, the loss of the toe of the diagram, the waste expansion between the cylinders and other causes of loss, that these also can be expressed as a simple linear function of the horse power.

Now, in the first edition of his treatise on the steam engine, which appeared in 1878, Prof. Cotterill had seriously attacked the problem of cylinder condensation from the theoretical side. Prof. Cotterill found it possible to give a partly rational, partly empirical formula for cylinder condensation.

But, according to his formula for unjacketed simple engines, the initial condensation has a fixed ratio to the steam present at cut-off. In the diagram, lines for steam present at cut-off are given, calculated in the manner already described. Above these has been set up the condensation by Cotterill's law, and the total steam consumption at various loads is then given by a line very nearly straight and closely agreeing with a Willans' line.

The curves on the two diagrams agree well with Willans' results, and they differ from Willans' lines in being obtained entirely by calculation without experimenting on the engine. It would not be right to make too much of the coincidence, but I thought it would be interesting to show that theory and experiment converge. A good deal has yet to be explained, but the discussion in Prof. Cotterill's treatise has done more than anything else to throw light on the conditions which promote or hinder cylinder condensation, and on the means useful in securing economy of working.

Since 1845, purely scientific men, scientific experimenters and practical engineers have all been engaged in the study of the steam engine. I do not believe that any one of the three can claim all the credit for the improvement of the steam engine to the exclusion of either of the others.

IMPROVED OIL FILTER.

WE illustrate from Engineering a compact and neatly designed form of filter recently introduced by Messrs. Allev & MacLellan, of the Sentinel Works, Glasgow, and specially intended for purifying the feed water for the boilers of condensing engines, separating from it any oil which it may have entrained during its passage through the engine. The device consists of a cast iron casing (Fig. 1) forming the support for the gun metal casting shown in Fig. 4, into which are screwed six tubes, closed at their upper ends, but grooved longitudinally, as shown in the figure. These tubes form supports for sleeves or mantles of filtering material. These sleeves are shown separately and also in place in Fig. 4. The water to be purified is admitted to the outside of these sleeves, and percolating through them gains access to the slotted tubes, passing down them into the boiler feed pipe. The filtering area is arranged to be about 250 times the area of the feed pipe, so that a slow rate of flow only is needed through the filtering material. When the mantles begin to get choked, they can very easily be replaced by slackening a couple of bolts and removing a small cover. Access is thus gained to the mantle beneath, and after replacing this with a new one, the whole casting carrying the tubes is turned through one-sixth of a revolution, bringing a second mantle under the opening. In this way the whole of the filtering material can be easily and rapidly renewed.

MOLTEN METAL BY RAILWAY.

IN the SCIENTIFIC AMERICAN of June 22 we noticed a novel system of transportation of molten metal. The following particulars, for which we are indebted to the Cleveland Leader, describe the system in more detail.

The Cleveland Rolling Mill Company has just completed a successful experiment in connection with the manufacture of steel which will save the company one dollar on every ton of steel, or about $200,000 every year, and will besides improve the quality of the finished product very materially.

The experiment was a novel one, and to the uninitiated mind it must seem audacious. It is, in brief, the transportation of immense ladles filled with molten metal over a railroad used by passenger and freight trains for a distance of five miles. Within an hour after the molten mass has streamed through the tapping hole of the central blast furnace it may, if necessary, be in the converter from which it comes out molten steel.

The object of the experiment, which was begun less than a month ago, and which it has just been decided is an unqualified success, was a triple one—to save money, to save labor, and to improve the quality of the steel. All these objects have been attained, and the new method will be used henceforth.

The old method of transporting iron from the central blast furnace on the flats, near the central viaduct, to the rolling mills in the South End, was a tedious and expensive one. Formerly when the furnace was tapped and the metal in a molten condition poured out, it was conducted in the runners, or grooves, in the sand below to the "pig bed." The "pig bed" consists of a main central groove or trough in the sand, through which the metal runs, and hundreds or thousands, according to the magnitude of the works, of smaller grooves in the sand below the furnace, into which it is conducted and where it becomes cold and hard, maintaining the shape of the groove, becoming what is known as a pig of iron, that is, a block about three feet long and weighing about two hundred pounds. In the old way, which is that usually followed, when they became hard these pigs were broken up, loaded in cars and transported in that way to the mills, where they were remelted, so that they might be ready for the converter. This necessitated the employment of a number of men to break up the pigs, a number to load them, a number to unload them and take them in barrows to the cupola for remelting, and it was, besides, a slow process.

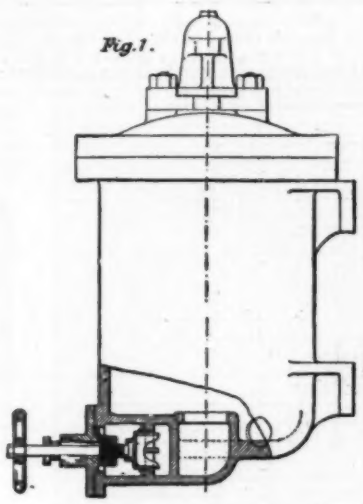
By the new process the handling of the pigs of iron at the blast furnace is saved and also their second handling at the mills, the coke used formerly in remelting is saved, the waste of metal by the second melting in the cupola is saved, and the metal is prevented from acquiring the sulphur from the coke in remelting as well as other impurities which would decrease the amount of the ferromanganese. The total estimate as approximated by Manager Craig, of the mills, is $1 per ton of steel saved or $200,000 every year, which is no small item.

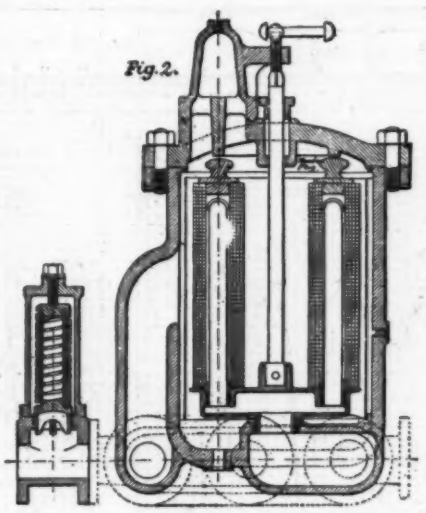
A reporter, accompanied by an artist, witnessed the new process recently, and enjoyed the privilege of riding five miles on an engine which pulled a train of four ladle cars, each ladle car containing seventeen tons of molten metal. The four cars, each bearing a gigantic ladle, not unlike a huge soup tureen in shape, but with a nozzle or spout on one side, are first carried into an underground open tunnel and placed in position directly under the mouths of four runners or grooves in the sand, through which the molten metal from the furnace flows. Then the blast furnace is tapped and the fiery burning, molten mass of metal rushes in four streams through the runners. When it reaches their mouths it drops into the ladles below, sending out showers of sparks. As soon as the ladles are full the runners are dammed, with the exception of the main channel, which then conducts the surplus metal directly across the tunnel over a cast iron bridge, into a pig bed. Here the old process is used for the surplus. But in the pig bed, where thirty-two men formerly worked, only six are now employed. The runners which conduct the metal to the ladle are sixty feet in length.

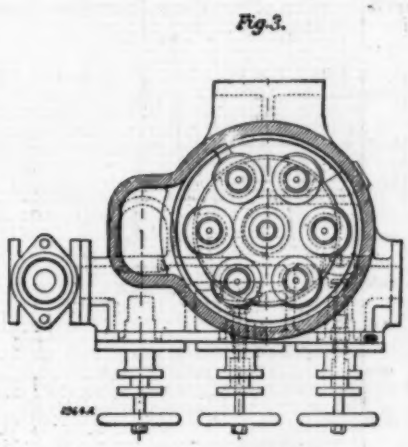
As soon as the ladles were filled the train was coupled together and an engine backed it to the Nypano's tracks, where one of that road's engines was attached to the train, and the twenty minute run to the South End was begun.

The metal train, as may be supposed, has the right of way over all other trains. Fancies of a collision and mind pictures of the air filled with molten metal, with a ton or two oozing under the thinker's collar and slowly finding its way to the small of his back were entertained. The fancy of a wreck of the train in the vicinity of a Standard oil tank, to which the tracks are adjacent, came up. The train had no hairbreadth escapes, however, but brought its molten cargo into the rolling mill yards amid considerable blowing of whistles and ringing of bells.

The cars were immediately pulled up to the shed in which are the gigantic mixers. Then one car at a time was hauled up on an elevator which had a lifting capacity of 180 tons. From the elevator the ladle was tipped slowly over until its molten contents were poured into the huge caldron-like affair called a mixer, which has a capacity of 120 tons of molten metal.







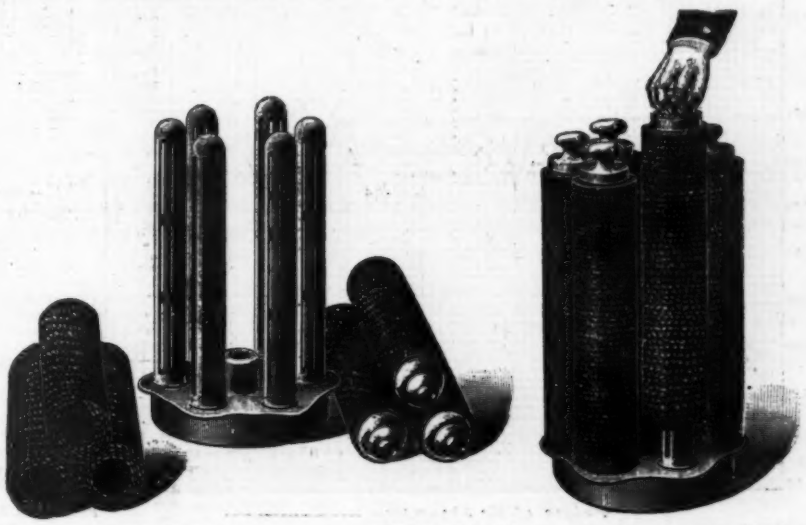


Fig. 4.

IMPROVED OIL FILTER.

TREATMENT OF ROASTED GOLD ORES BY MEANS OF BROMINE.

IN a communication presented at the last meeting of the American Institute of Mining Engineers, Richard W. Lodge stated that H. R. Batcheller, of the Massachusetts Institute of Technology, experimented on the effect of bromine on a lot of ore similar to some upon which chlorine had given poor results. The material worked on consisted of concentrates containing 2·31 oz. of gold per ton and 34·26 per cent. of arsenic. There was some pyrite, galena and chalcopyrite also present. The ore was roasted from five to eight hours. Five hundred grammes of ore were taken and 1·5 c. c. bromine and 500 c. c. water. In a number of experiments made it was found that after one hour the extraction was 72·02 per cent.; in two hours, 81·35 per cent.; in three and a half hours, 86 per cent.; in four and a half hours, 88 per cent.; in five and a half hours, 92·54 per cent. In the experiments with a larger quantity, using 15 kilos of ore, 15 kilos of water and 35 kilos of bromine, an extraction of 92·18 per cent. was secured in five hours. The actual gold recovered from the solution was only about 80 per cent., which is explained by the presence of considerable copper.

[FROM THE ENGINEER, LONDON.]

THE TIN PLATE INDUSTRY IN THE UNITED STATES.

THAT the American tin plate industry has developed to a point at which it enters into very serious competition with the British industry is a fact which admits of no doubt, and the inquiry into the development and present condition of the industry which has been undertaken for the purpose of these articles has been conducted with a view to obtaining and presenting the plain, straight facts of the case, without regard to commercial or political prejudices. Probably few British manufacturers realize the rapid and steady development of the industry in the United States, or have foreseen the probability of American manufacturers not only supplying all domestic demands, but also seeking to enter the lists for competition for the trade in other countries. Previous to 1890, tin plates were only manufactured to a limited extent, more for experimental than commercial purposes; but the tariff bill of that year, which raised the duty on imported tin plate, gave a great impetus to the home industry, and since that time the progress has been steady and great, so that the industry is now firmly established on a sound commercial basis.

About 1868 Mr. James Park and the Cambria Iron Company sent men to Europe to investigate the tin plate works in England, Wales, France, and Germany, but their reports were to the effect that while the United States had good facilities for carrying on this industry, it would not be possible to pay the rate of wages then ruling in the United States and yet compete with European manufacturers, unless the government rendered some protection or assistance. In spite of this however the high prices of foreign tin plate led to some attempts to establish home manufacture, and works were built and tinned plates made at Leechburg, Pa., Wellsville, O., and Demmler, Pa., between 1872 and 1875. After overcoming many difficulties incident to the commencement of a new industry, the works began to prosper, and turned out a product that was satisfactory to consumers. The Welsh manufacturers, however, seeing the possibility of a competition that might be ruinous to their trade, began at once to cut the price, gradually reducing it from $13 —£2 12s. 6d.—to $4.50—18s. 9d.—per box. The American works, therefore, eventually succumbed, as they could not sell their product at such a price with any profit, and the home industry was therefore practically killed, or rather smothered for the time being. This, however, was the beginning of a struggle which, within the past year or two, has practically turned the tables on the Welsh makers, and as already remarked, it seems not improbable that the American makers will soon be turning their attention to foreign markets. After the failure of the works established in 1872 75 there was a period of rest, but in 1889 tinned plate was made in limited quantities at Pittsburg, Pa., and at Martin's Ferry, O.

In regard to the use of Bessemer steel plate for tinning, it is stated that in 1876 the late Captain William Jones, superintendent of the Edgar Thomson Steel Works, and the late Mr. John Cole, superintendent of the United States Iron and Tin Plate Company, concluded that Bessemer steel could be profitably used as a substitute for charcoal iron, and billets were made by Captain Jones which were actually made into tinned plate by Mr. Cole. This introduced a great economy in manufacture, but not enough to compensate for the difference between the labor wages then prevailing in Europe and in the United States. Tinned plates of Bessemer steel are said not to have figured in the English market reports until 1878 or 1879.

The variations of the duty on tinned plate imported to the United States have been as follows:

1867—1873....	25 per cent.
1873—1875. .	15 per cent.
1875—	15 per cent. and $1\frac{1}{10}$ cents per lb.
1876—.... ...	15 per cent. and $1\frac{1}{10}$ cents per lb.
1876—1883....	$1\frac{1}{10}$ cents per lb.
1884—1891....	1 cent per lb.
1891—1894....	2·2 cents per lb.
1894 and 1895.	1·2 cents per lb.

The imports of tin plate from 1867 to 1894 are given in Table I. and the figures show the steady increase which continued until the high tariff went into effect, when a decrease was at once apparent, owing to the development of the home product. The table shows also the tin plate imported for export trade, the imports of tin, and other interesting statistical matter, compiled and arranged in such a way as to show the general development since 1867. The figures given are official, having been furnished by the Treasury Department for the purpose of my report. The values in pounds sterling are approximate only, taking five dollars to the pound, but these converted values will be acceptable to English readers.

When the high tariff bill, popularly known as the McKinley bill, was under discussion, the opponents of the bill, especially those opposing the tin plate clauses, argued, 1, that it would be foolish thus to protect an industry that could hardly be said to exist; 2, also that higher prices would thereafter be made for home tin plate, thus either raising the price of canned—or tinned —goods to the consumer, or reducing the price paid to the farmer for goods to be canned; 3, and further, that it would be impossible for the United States to produce enough for home consumption. In other words, they argued that the industry did not exist, could not exist, and if it did exist, could not meet the demand and would raise prices. The development of the industry since that time, however, and its commercial success may be taken as practical answers to these arguments, and may serve as a warning against accepting such predictions on the part of other opponents to progress, whether influenced by general principles or by interested motives.

Returning to the political steps, the McKinley bill was passed on October 1, 1890; but the tin plate clause provided that the new and higher duty on that commodity should not go into effect until July 1, 1891, in order to give time for establishing works, and for making the necessary arrangements for manufacture. The election of November, 1890, brought into office a House of Representatives which was understood to be opposed to the high tariff, and this had a somewhat depressing effect upon the industry, as manufacturers hesitated to incur the expense of establishing factories. At the same time the British manufacturers took advantage of the situation by raising the price of their product 20 to 30 per cent., thus directly antagonizing their American customers. The imports of tin plate, terne plate, and taggers plates from Great Britain for the three fiscal years ending June 30, 1890, 1891, and 1892, were as follows, showing that the abnormal importations for 1891, and the consequent overstocking of the American market, were not encouraging conditions for the new industry:

1890....	680,060,095 lb.	
1891 ...	1,036,489,074 lb.	{ 356,428,149 lb. increase (or 52 per cent.)
1892 ...	422,176,202 lb.	..614,312, 872 lb. decrease.

The tin plate clause of the Tariff act of October, 1890 —the McKinley bill—was as follows:

1. All iron or steel sheets or plates, and all hoops, band or scroll iron or steel, excepting what are known commercially as tin plates, terne plates and taggers tin, and hereinafter provided for when galvanized or coated with zinc, or spelter, or other metals, shall pay three-fourths of one cent—three-eighths of a penny—per pound more duty than the rates imposed upon the corresponding gages or forms of common, or black sheet, or taggers iron or steel.

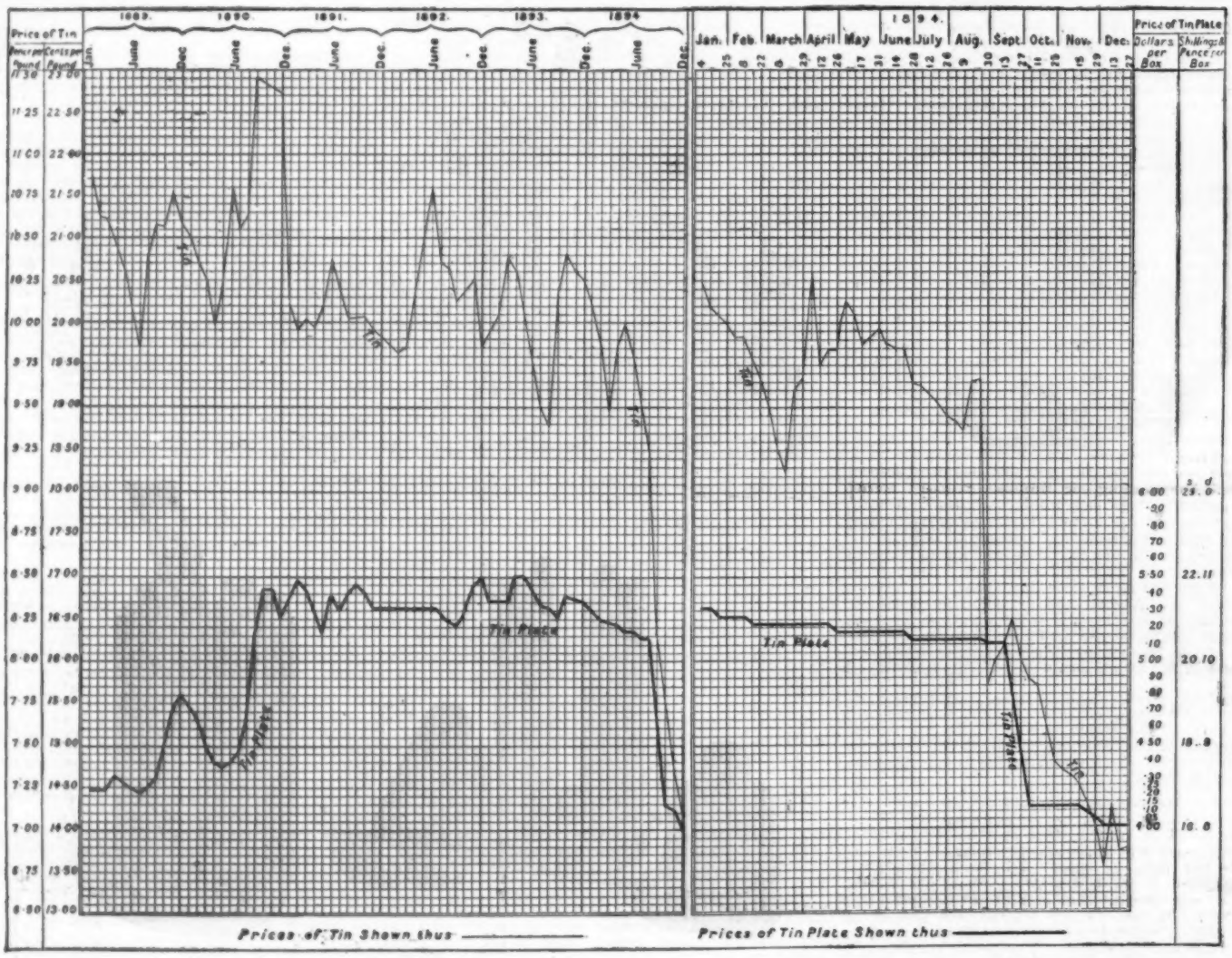
2. On and after July 1, 1891, all iron or steel sheets or plates, or taggers iron coated with tin or lead, or with a mixture of which these metals, or either of them, is a component part, by the dipping or any other process, and commercially known as tin plates, terne plates and taggers tin, shall pay two and two-tenths cents—$1\frac{1}{10}$ pence—per pound.

3. Provided, that on and after July 1, 1891, manufactures of which tin, tin plates, terne plates, taggers tin, or either of them, are component materials of chief value, and all articles, vessels or wares manufactured, stamped, or drawn from sheet iron or steel, such materials being the component of chief value, and coated wholly or in part with tin or lead, or a mixture of which these metals or either of them is a component part, shall pay a duty of fifty-five per cent. ad valorem.

4. Provided, further, that on and after July 1, 1897, tin plates and terne plates lighter in weight than 63 lb. per hundred square feet shall be admitted free of duty, unless it shall be made to appear to the satisfaction of the President—who shall thereupon by proclamation make known the fact—that the aggregate quantity of such plates lighter than 63 lb. per hundred square feet produced in the United States during either of the six years next preceding June 30, 1897, has equaled one-third the amount of such plates imported and entered for consumption during any fiscal year after the passage of this act, and prior to said October 1, 1897.

5. Provided that the amount of such plates manufactured into articles exported, and upon which a drawback shall be paid, shall not be included in ascertaining the amount of such importations.

6. And provided further, that the amount or weight of sheet iron or steel manufactured in the United States, and applied or wrought in the manufacture of articles or wares tinned or terne plated in the United States, with weight allowance as sold to manufacturers or others, shall be considered as tin and terne



plates produced in the United States within the meaning of this act.

In 1894, however, an act was passed reducing the duty on tinned plate, terne plate and taggers tin to 1·2 cents—$\frac{6}{10}$ of a penny—per pound, which considerably affected the industry, but there are no signs of this ad- the same time that they were only 10 cents—5d.—per hundred pounds from the port of importation.

The tin plate industry was made the subject of investigation by the government, and Mr. Ayer, the special agent of the treasury department, has presented a report covering the three years from July 1, 1891, to

were terne coated. The quantity of American sheet iron and steel made into articles and wares tinned or terne plated was 1,807,854 lb. This makes the aggregate output of tin and terne plate for the quarter, from all sources, 48,274,189 lb., while the total for the previous quarter was 40 423,300 lb.

TABLE No. I.—*Statistics of United States Commerce in Tin-plate and Tin, 1867-1894.*

Year ending June 30th.	Dutiable tin-plate imported.								Exports of foreign tin-plate.			Tin imported.								Imports of manufact'res of tin-plate.		Domestic exports of manufactures of tin-plate.		Foreign exports of manufactures of tin-plate.	
	Quantity, lbs.	Value, dols.	Value, £.	Rate of duty.	Amount collected, dols.	Amount collected, £.	Price per lb. cents.*	Price per lb. pence.*	Quantity, lbs.	Value, dols.	Value, £.	Quantity, lbs.	Value, dols.	Value, £.	Rate of duty.	Am'nt collected, dols.	Am'nt collected, £.	Price per lb. cents.*	Price per lb. pence.*	Value, dols.	Value, £.	Value, dols.	Value, £.	Value, dols.	Value, £.
1867	—	6,270,137	1,255,227	35 per cent.	1,569,034	313,807	—	—	455,200	32,538	6,516	—	1,210,354	242,071	15 per cent.	181,553	36,310	—	—	40,123	8 024	40,645	8 129	343	68
1870	153,515,000	7,628,573	1,525,774	do.	1,907,218	381,443	5·7	—	336,000	22,030	4,405	8,170,200	2,042 867	408,577	do.	306,483	61,283	—	—	58,622	11,724	45,007	9,201	929	185
1875	81,500,700	7,490,508	1,496,101	do.	1,122,000	224,400	9·1	—	478,400	37,849	7,469	10,299,400	2,223,488	465,897	Free.	—	—	—	—	31,706	16,341	45,194	9,039	1500	703
	31,165,646	5,077,122	1,015,424	1⅕ cents per lb	892,822	178,564	6·8	—																	
1880	369,435,844	16,894,590	3,304 918	do.	4,068,794	812,759	4·5	—	695,800	36,319	7,264	29,006,694	6,153 005	1,230,601	do.	—	—	19·5	9·75	62,805	12,561	144,189	28,837	1016	203
1885	503,559,076	16,610,105	3,322,021	1 cent per lb	5,035,591	1,011,118	3·3	—	491,571	17,286	3,457	23,947,523	4,263,447	852,689	do.	—	—	17·9	8·95	51,841	10,368	102,304	22,461	Included with other metal manufactures.	—
1890	674,684,458	20,746,423	4,149,285	do.	6,746,845	1,349,329	3·1	—	1,550,229	45,905	9,161	34,963,090	6,838,909	1,379,782	do.	—	—	20 0	10·0	49,606	9,921	294,896	56,979		—
1891	1,057,711,501	36,255,580	7,271,116	do.	10,577,155	2,115,423	3·4	—	1,287,135	44,834	8 971	39,677,041	7,977,545	1,595,509	do.	—	—	20·0	10·0	48,471	9,694	240,836	49,967		—
1892	5,449,281	209,443	41,888	do.	54,493	10,899	3·4	—	620,175	18 835	3,767	43,912,643	8,067,683	1,733,573	do.	—	—	20·0	10·0	49,614	9,923	225,113	45 022		—
1893	397,587,504	11,583,856	2,316,771	2·2 cents per lb	8,746,925	1 749,385	2·9	—	1,219,257	35,541	7,108	60,907,839	12,222,801	2,464,560	do.	—	—	20·0	10·0	60,788	12,350	223,441	44,688		—
1894	496,780,713	11,655,080	2,331,123	do.	9,939,175	1,921,835	2·7	—	719,161	20,210	4,042	14,294,140	2,258,345	451,669	4 cents per lb.	571,765	114,353	15·7	7·85	45,395	9,079	290,494	58,099		—

* NOTE.—These are the average prices or costs in the foreign market from which the plate or tin was shipped to the United States.

verse legislation having any tendency to kill the industry as a whole, although the more unfavorable conditions consequent upon this legislation compelled some of the smaller firms to go out of business. The trade suffered in 1894 not only from the general commercial depression, but also from the long-continued uncertainty as to the result of legislative talk and inaction on the tariff question. In August, 1894, the new tariff act was finally passed, reducing the duty on tin plate from $2\frac{2}{10}$ cents to $1\frac{2}{10}$ cents per pound—$1\frac{1}{10}$d. to $\frac{6}{10}$d.—this new duty going into effect on October 1, 1894. Sales at once began to decline, as consumers postponed all orders, except such as were required to meet immediate needs, until they could take advantage of the drop in prices, which was expected as soon as the lowered duty should go into effect. In October the prices, of course, fell as expected; but the demand for plate was not as great as had been expected, and the trade continued dull down to the end of the year, while the reintroduction of Welsh roofing plates forced to the wall some of the smaller works which did not make their own black plate. The dullness in building trades and the canning—or tinning—industry were also among the causes of a small consumption and poor business. In some cases the unfavorable conditions of tariff and trade led to a cost of 75 cents to $1.25—3s. 2d. to 5s.—per box on domestic tin and terne plate. The severe competition between home manufacturers and between home and foreign manufacturers, the commercial depression, the labor troubles, and the greatly reduced margin of profit, are not very encouraging conditions; but it seems certain that the industry is now too strong and too firmly established to be killed or seriously injured, especially as the home product has a favorable reputation as to quality.

The diagram, which is taken from a record of fluctuations in the prices of metals in the Iron Age, shows the monthly range of prices of tin and tin plate from January, 1889, to December, 1894, and the weekly range during 1894.

In January, 1895, it was reported that the market was demoralized, and that the outlook was not encouraging. Canners of most varieties of vegetables had had such poor returns from their enormous output of last year that they were lessening their operations for the coming season, and were, therefore, very indifferent buyers of plates. Fruit and meat canners were in much the same case, and other consumers were not making the average January purchases. Under these conditions the competition was keen, and kept prices low and irregular. At the beginning of March, 1895, business was still surprisingly light, the reported suspension of work at various foreign mills, and the reduced output at others, having failed to enliven buying interests and not appearing to have curtailed the amount offered. These conditions served to keep the market in a remarkable state of weakness, and where necessary to secure or retain trade, American manufacturers had met foreign prices, thus adding to the weakness, while in some cases the prices for American plate had been lower than those quoted for foreign stock of like character. Toward the end of March, however, the long period of dullness was broken, the low prices having at last stimulated purchasers, while the depletion of foreign stocks, due to the forced curtailment of production, also aided the sellers.

The price of tin declined steadily during 1894, and the formation of a European syndicate to control a "corner" in tin, in view of the expected removal of the duty of 4 cents—2d.—per pound, which had been established by the McKinley bill, had but little effect on the market. When the new tariff act of 1894 restored tin to the free list, very little purchasing had been done, and the "corner" was eventually abandoned. The prices of tin per pound during 1894, as given in the market reports of the Iron Age, are shown in Table II.

A somewhat singular feature is that the railways in making freight rates on tin plate have discriminated against the home manufacturer in favor of the importer, and this, of course, has been felt most seriously by the Western manufacturers. Thus, for instance, Chicago is only 165 miles from some of the large works in Indiana, and is nearly 1,000 miles from New York, yet the freight rates to Chicago have been 9 cents—4½d.—per 100 lb. from the Indiana factory at

Table No. II.—Prices of tin in the United States, 1894.

	Cents.	Pence.
January 4	20·50	10·25
February 1	19·85	9 925
March 1	19 00	9·50
April 5	20·50	10·25
May 3	20·25	10·125
June 7	19·80	9·90
July 5	19·25	9·625
August 2	18·75	9·375
September 6	16·00	8·00
October 4	15 75	7·875
November 1	14·65	7·325
December 6	13·50	6·75
January, 1895	13·45	6·725
February, 1895	13·10	6·55

June 30, 1894, and Table No. III, dealing with the domestic manufacture, has been compiled from the figures of that report:

TABLE No. III.—*Tin-plate Production in the United States, 1891-1894.*

Year.	Tin-plate.			Terne plate.			Tin and terne plate Aggregate production.	Amount made from				Grand total.
	Lighter than 63 lb. per 100 sq. feet.	Heavier than 63 lb per 100 sq feet.	Total.	Lighter than 63 lb. per 100 sq. feet.	Heavier than 63 lb per 100 sq. feet.	Total.		American black plate.		Foreign black plate.		
	Lb.	Lb	Lb	Lb.	Lb.	Lb.	Lb.	Lb.	P. cent	Lb.	P. cent.	Lb.
1891–92	4,182,009	407,581	4,589,590	8,194,536	914,593	9,107,129	13,646,719	9,296,558	68·12	4,350,166	31·88	13,646,719
1892–93	42,370,681	3,372,426	45,743,107	51,479,806	2,596,289	54,076,055	99,819,202	43,599,724	43·68	56,219,478	56·32	99,819,202
1893–94	77,480,825	4,188,940	81,669,765	55,598,417	2,020,285	57,613,702	139,223,467	85,968,202	61·74	53,555,265	38·26	139,223,467
Total, 3 years	123,923,515	7,968,947	131,892,462	115,265,759	5,581,167	120,796,926	252,689,388	138,864,479	54·95	113,824,909	45·05	252,689,388

In Table No. IV are given, for the same three years, the amount of American sheet iron and steel made into articles and wares tinned or terne plated, and also the amount of the production of American fine sheet steel or black plates:

TABLE No. IV.—*Production of Tinned Articles and Black Plates in the United States, 1891-1894.*

Year ending June 30th.	American sheets made into tioned articles.	Production of American fine sheet steel or black plates.		
		Lighter than 64 lb. per 100 sq. ft.	63 lb. per 100 sq. ft. and heavier.	Total.
	Lb.	Lb.	Lb.	Lb.
1891-92	5,620,867	7,620 927	18,568,329	26,219,256
1892-93	8,802,681	40,892,420	2',789,121	62,681,541
1893-94	6,268,263	81,308,842	17,662,038	98,970 880
Total, 3 years	20,691,911	129,828,189	59,037,488	186,865,677

And finally, to close this series of tables of statistics, Table No. V shows the quantity of tin plates and terne plates imported and exported during the quarter ending June 30, 1894, which was the last quarter covered by the special investigation above referred to.

In this table the imports include the quantity of tin plates and terne plates imported and entered for immediate consumption, and of such as were imported on and after July 1, 1891, and were withdrawn from the bonded warehouse for consumption during the quarter. The exports include the quantity of tin plates and terne plates on which duties had been paid, and which were used in the manufacture of articles exported with benefit of drawback during the quarter.

In his report for this same quarter ending June 30, 1894—the last covered by this investigation—Mr. Ayer stated that during that quarter forty firms manufactured 46,466,335 lb. of tin plates and terne plates, as compared with thirty-six firms and 38,260,411 lb. of product during the previous quarter. Of the 46,466,335 lb. aggregate output, 33,501,344 lb.—or more than 72 per cent.—were made from sheets rolled in the United States, and of this amount 32,477,703 lb.—or about 97 per cent.—consisted of the class of plates weighing less than 63 lb. per 100 square feet. Of the commercial plates manufactured during the quarter, 26,752,998 lb. were coated with tin and 19,713,339 lb.

From the figures given it is shown that during the fiscal year ended June 30, 1894, American manufacturers produced of tin and terne plates, as defined in the tariff law, solely from sheets rolled in the United States, 9,334,106 lb. in excess of the net imports during the fiscal year ended June 30, 1892. While in 1894 Mr. Ayer's report showed that 72 per cent. of the output was made from American black plate, it is estimated that at the present time over 80 per cent. of the output is from American black plate.

The production of black plates in the United States during the quarter ended June 30, 1894, was 37,864,901 lb., and of this amount 32,449,205 lb., or more than 85 per cent., belonged to the class weighing less than 63 lb. per 100 square feet, while in the previous quarter the production was 30,070,701 lb., of which 23,514,881 lb., or more than 78 per cent., were of the lighter class. The production of American black plates of this lighter class was 8,934,324 lb. in excess of that of any previous quarter, and twenty rolling mills made sworn returns of production, against eighteen mills making returns for the preceding quarter.

Of the forty firms mentioned as having made sworn returns of the manufacture of commercial tin and terne plates, twenty used American plates exclusively, with an output of 25,558,798 lb.; five used foreign plates exclusively, with an output of 4,700,197 lb.; and fifteen used both foreign and American plates, with an aggregate output of 16,207,340 lb., of which 7,943,546 lb. were made from American black plate.

Of the stamping or other manufacturing companies that used American sheet iron and steel in the manufacture of articles and wares tinned or terne plated, sixteen submitted sworn statements of production, as against fourteen in the preceding quarter.

(To be continued.)

TABLE No. V.—*American Imports and Exports of Tin-plates and Terne plates during the Quarter ended June 30th, 1894.*

	Imports.			Exports.		
	Lighter than 63 lb. per 100 sq. ft.	63 lb. per 100 sq. ft. and heavier.	Total.	Lighter than 63 lb. per 100 sq. ft.	63 lb. per 100 sq. ft. and heavier.	Total.
	Lb.	Lb.	Lb	Lb	Lb.	Lb.
Tin-plates	108,739,652	1,765,417	110,505,069	88,402,005	99,500	26,501 [illegible]
Terne "	9,004,216	40,802	9,031,019	84,884	—	[illegible]
Total..	117,743 868	1,812,220	119,536,088	36 486,691	99,500	36,586,191

QUICKSILVER ORES AT GUADALCAZAR, MEXICO.

By W. H. RUNDALL.

ALTHOUGH ores of quicksilver are reported to have been met with in almost every State in Mexico, there are only two points in the republic at present where these ores are being mined and treated on anything like a large scale. These are Huitzuco, in the State of Guerrero, south of Mexico City, and Guadalcazar, in the State of San Luis Potosi.

In the Huitzuco district there is one principal mine

being worked. The ore is cinnabar, intimately mixed with sulphide of antimony, and is treated in large shaft furnaces, from 60 to 100 flasks of quicksilver being produced per week. This mine was first discovered in 1872 by a Frenchman named Thevenet, who recognized cinnabar in the stone used for building walls and houses in the neighborhood.

In Guadalcazar the existence of cinnabar, or vermilion, seems to have been well known to the Indians before the advent of civilization, though they probably never attempted, and did not know how, to extract the quicksilver therefrom, but used the vermilion as paint.

This district first came into prominence about the middle of the century, when the Mexican government, in order to encourage the production of quicksilver in a country where so much is used in the treatment of silver ores by the "patio" process, offered a considerable sum of money as a prize to the owner or owners of the mine within the limits of the republic that would produce the largest quantity of quicksilver in a given year. This prize was gained by the owner of a mine in the Guadalcazar district, now owned and worked by an English company.

That the government is still anxious to protect and encourage as much as possible the production of quicksilver in this country is proved by the fact that, by the new Mexican mining law which came into force in 1893, all mines are obliged to pay a yearly tax of $10 per "pertenencia," that is, for every 10,000 square meters over which their mining rights extend; in the case only of quicksilver mines was this tax reduced from $10 to $1 per "pertenencia."

Guadalcazar is a small town lying about 70 miles to the southeast of the town of San Luis Potosi, and about 14 miles from Villar station, on the Tampico branch of the Mexican Central Railway. It lies in the midst of a hilly limestone country, the limestone rarely showing signs of stratification and being absolutely destitute of fossils, for which reason it is difficult to assign any age to the formation.

To the northwest of Guadalcazar the limestone is interrupted by a huge mass of porphyry and granite, forming a hill which towers 1,800 feet above the level of the town, and round the base of which exist several veins containing a great variety of minerals. Most of these veins show signs of having been extensively worked, and, according to tradition, at the end of the last century, ores rich in silver were mined at great profit in this district. At the present day one or two mines are being worked on a small scale for silver, but with little or no results. Low grade silver ores exist in great abundance, but owing to a scarcity of lead ores and abundance of zinc blende, they are unsuitable for smelting and have been found refractory for amalgamation.

The quicksilver deposits run in a northwesterly direction from the town, skirting the porphyry formation. These deposits occur almost entirely in the limestone and are traceable at intervals over a distance of about 30 miles. The most important and extensive deposits occurring, however, at a distance of from four to nine miles of Guadalcazar and at elevations of from 400 to 700 feet above that town. The two most important producing mines are the Trinidad, owned by an English company, and the Nuevo Potosi, owned by a local company.

The Nuevo Potosi mine, which had been more or less abandoned for several years, and which had been extensively worked by tributers in the days when quicksilver was fetching a good price, was taken over by a local company about a year ago. The ore yielded by this mine is of very poor quality, averaging from one-half to one per cent. of quicksilver, but owing to the ore occurring in large and more or less easily mined bodies, and the cheapness of native labor, wood fuel, etc., these ores can be worked at a fair profit.

The occurrence of the ore is very curious. The country rock is entirely limestone, much broken up and shattered in parts and with no apparent stratification. Almost at any point near the surface an excavation will discover small isolated patches or eyes of pure crystalline cinnabar in the limestone, but not in sufficient quantity to be workable. In quarrying stone for building purposes, one almost always encounters these eyes of cinnabar, whereas the inclosing stone contains no trace of mercury. The workable ore occurs in connection with a series of highly irregular stringers or shoots of clay, the ore sometimes occurring actually in and associated with the clay and sometimes forming bodies or branches on the hanging wall or the foot wall of the clay shoots. The clay, when containing mercury, is of a dark brown or blackish color and mixed with broken fragments, from the size of a pea to that of large bowlders, of a dark colored shale, the shale being sometimes colored bright red with decomposed cinnabar or vermilion, but more often containing the mercury as metacinnabarite or black ore. Picked stones of this black shale will assay 2 or 3 per cent. of mercury, but rarely higher. Both the shale and the clay contain considerable quantities of fluorspar and carbonate of lime, and sometimes a little barytes or heavy spar. In the neighborhood of the clay shoots the limestone rock will often contain impregnations of ore over a considerable area, but the ore is generally of such low grade that it cannot be mined at a profit. These large masses of low grade ores in the limestone appear to be highly shattered masses of country rock which have been recemented into a solid stone by filtrations of carbonate of lime, but a careful study of the stone makes it doubtful that these filtrations were the means by which the mercury was deposited. The ground in and around the clay shoots, though soft, is compact and stands well as a rule, though in parts the clay is split up by numerous slicken sides, which render it somewhat treacherous, especially after a few weeks' weathering. Where the distance between foot and hanging wall does not exceed 2½ or 3 meters, timber props are found sufficient support. Where this distance is exceeded, a system of filling, strengthened and held in place by rough masonry, has been adopted.

The ore is extracted through a vertical shaft; the contour of the ground rendered it possible to drive an exploration adit into the hill at a depth of 130 meters below the surface at the shaft. In the adit level the limestone was found to be highly altered in parts, becoming much softer, black in color, with traces of bituminous matter, and emitting, when struck, a powerful odor of sulphureted hydrogen. This altered stone was generally found to contain traces of mercury. Although no bodies of ore have been discovered as yet in the adit, several small pockets of considerable richness occurred at different points. The lowest point to which the main ore shoot has been followed is 85 meters below surface at the shaft, that is to say, 45 meters above adit level, and there seems reason to believe that the ore will increase in richness as a greater depth is attained, owing to the greater richness of the small pockets of ore found in the adit level.

The ore on coming from the mine is tipped over screens to separate the smalls or "tierras" from the larger stones. The tierras are taken direct from the screens and tipped into ore bins of 10 tons capacity, being sampled en route in order to obtain the assay value of each bin. The larger stones are first picked over and then broken down to pass a ¾ inch ring. The broken ore or "granza" is then sampled and tipped into bins in the same way as the "tierras" or smalls.

The ore is treated in muffle furnaces with cast iron condensers and brick sedimentation chambers, the mercury being drawn off once a week.

The Trinidad mine, situated about nine miles northwest of Guadalcazar, is the most important in the district. This mine has been in the hands of an English company for the last four years.

The formation is limestone, but differs from the Nuevo Potosi mine in that the limestone has been largely replaced in parts by gypsum. This forms huge bodies highly irregular in form and sometimes many hundreds of meters in extent, cropping out to surface in patches, but with no apparent regularity of any kind.

The occurrence of the ore in this mine is very irregular, but there may be said to exist one main ore shoot which has been followed through a horizontal distance of about 200 meters and a vertical distance of about 60 meters. The upper part of this shoot consisted of a mass of irregular stringers of ore running in all directions through broken-up limestone rock and forming stringers and pockets in the solid gypsum, which in turn occurs in irregular but connected masses, replacing the shattered country rock or limestone. In parts these stringers would become so numerous, intersecting each other in all directions, that it would be necessary to stope away ore and waste rock promiscuously, care being taken, however, by the miners not to mix them.

As the ore shoot was followed and explored in depth the ore took a more massive form, occurring in large bodies and increasing in richness. At one point a large body of soft black ore was discovered, averaging from 7 to 10 per cent. of mercury, completely inclosed within a solid mass of gypsum. The ore, when occurring in the gypsum, is usually a mercury selenide of an iron gray color, granular, soft, and giving a purple streak. Crystallization is rarely seen, but small needle-like crystals radiating from a center have been noted and preserved as specimens. Picked specimens will give from 10 to 15 per cent. mercury, and large quantities have been mined giving an average yield of 5 per cent. mercury.

In the lowest stopes the ore occurs in silicified limestone rock, in parts much shattered and considerably mixed with clear transparent gypsum and fluorspar. The ore is black or a dull brick red in color, and is somewhat poorer than that embedded in solid gypsum.

A little to the south of the ore-bearing workings the limestone is intersected by a dike of decomposed porphyry. This dike has been cut through at one or two points by the exploration workings, but nowhere shows any signs of ore. A similar dike cutting through limestone in the same district is yielding mercury ore of fairly good quality.

About 20 miles to the northwest of Guadalcazar exist a group of quicksilver mines, one of which has been opened to a considerable depth. The mines are said to have yielded good quality ore, and some is still in sight in the lower workings. These mines have been abandoned for many years, and, owing to the opposition of the owner of the surface ground, several attempts to reopen them have proved futile. Ores of quicksilver are very extensively spread over the whole of the country surrounding Guadalcazar, but only at the points mentioned have they been exploited on anything like a large scale.

Although no actual veins are known, cinnabar must occur also in the porphyry formation previously alluded to, as in the sand of the stream beds cinnabar mixed with pyrites containing a little silver and gold can be obtained by washing. In the wet season a good many natives make a living by washing this sand. The concentrates thus obtained have been known to yield 7 per cent. and 8 per cent. of mercury.—Engineering and Mining Journal.

WATER FOR PHOTOGRAPHY.

By DUNCAN MOORE.

THE purity and brilliancy of our transparencies and negatives are considerably influenced by the quality of the water used in their preparation. Chemically pure water exists mainly in theory, rather than for any available supply. Distilled water being the nearest approach to it we are likely to get, and that very often is far from what it professes to be. The mystical capitals HO represent the chemical constitution of water, but the component parts of the water we have to avail ourselves of would be more nearly represented by all the letters in the alphabet. Pure water consists of a mixture by weight of eight parts of pure oxygen gas with one part of pure hydrogen; if it contain anything else, it must exist as an impurity. The sea is the primary source of all water, by evaporation; it is carried over the land by clouds, and is discharged from them as rain, to afterward present itself as river, spring, and well water. Rain water, if collected at a long distance from towns, or manufactories, or other sources of contamination, and at a great altitude, is the purest form of natural water, but even under these conditions it is not absolutely pure, as a certain amount of foreign matter floating in the atmosphere is carried down with it. That, however, collected near towns is, on the contrary, extremely impure, the air being greatly contaminated with ammoniacal and other detrimental vapors that impregnate it, to say nothing of the thousand and one impurities in the dust lodging on the roofs, etc., from which the water is gathered. It is always best in collecting rain water from any source to allow the first of the shower to pass away into the drains before reserving any for photographic use. If this is done, and the water well filtered before use, it will be found tolerably pure, and good enough for most photographic operations. The most important photographic use necessitating pure water is making solutions of silver nitrate, in which case any contamination of organic or saline matter would cause decomposition. If it so happens that there is no choice of water, and a known impure sample is to be used, the best plan is to first boil it, in order to precipitate any lime, afterward add a few grains of silver nitrate and expose to the brightest sunlight available for a day or two. The organic matter will by this means be precipitated as a black mud, and although the water thus treated will not be absolutely pure, still it will be sufficiently so for most purposes, after filtering, in which silver nitrate has to be dissolved. Spring water and river water are next in order of purity, but (there is a great deal in this "but") it altogether depends on the soil through which the spring flows. Springs are caused by rainfall on higher grounds, through which they filter, and in their course dissolve any soluble matter in their passage. In chalky soil, spring water is saturated with lime, but is tolerably free from organic impurities. If we take such water, clear and sparkling as it may appear, for development in which oxalates are used, we immediately get into difficulties by a precipitation of oxalate of lime in our films, which causes a granular, muddy appearance, unfitting the transparency for lantern work; in fact, any development in which lime salts are decomposed or precipitated indicates that such water should be deprived of its lime by boiling for a considerable time. Lime, however, is not the only substance likely to be found in spring water; chlorides of various kinds, metallic impurities, more especially iron, magnesium, and soda, as we see by our medicinal and chalybeate springs. The earth surrounding and over which the spring flows, when iron is contained in solution, proclaims its presence by the rusty color of the precipitated oxides.

Sulphates and chlorides are, of course, not noticeable in this manner, but detectable by taste when they occur in important quantity. Hydrates are frequently present; in fact, almost always, their quantity or character depending mostly on the soil through which the water flows. Water is one of the most powerful solvents known, and at various temperatures few things are not more or less soluble in it; even glass is, by its long-continued action at a high temperature, corroded away. It is, therefore, easily understood how it almost becomes impossible for such a fluid to be anything like pure in a natural state. Water proceeding from glaciers and snow on lofty mountains is its purest form.

River water is a mixture of drainage and spring water, and of necessity much more impure, being additionally contaminated with organic matter in all forms. Putrefactive and excretive matter is being continually added, but by a fortunate dispensation of nature they soon became oxidized and deposited as mud, forming a nutritious soil for plants and vegetables of various kinds, the plants in their turn further purifying the water in which they grow by the absorption of various earthy salts that are contained in solution. So the process continually goes on—addition, decomposition, absorption and purification, until the main bulk of the stream becomes bright and usable. The pollution of the water by manufactories is sometimes carried to such an extent that a river becomes little better than a sewer. Water from such a source is evidently useless for photographic purposes, as no amount of filtering or subsidence will remove the obnoxious matter, distillation being the only possible means of making it suitable.

Rivers flowing through sandy and gravelly soils are generally purer than those where the bed is of a clayey or chalky character. River water is usually termed soft; that is, the sulphates contained in it are insufficient to curdle a solution of soap. Hard water, which contains a superabundance of these salts, has an opposite effect. Well water varies in its composition more perhaps than that from any other source; the depth of the well and kind of soil in which it is sunk, and the various sources of contamination that are in the vicinity which percolate into it. As a general rule, well water obtained from diluvial gravel above the clay is more impure than from the green sand at a lower level, and water from wells sunk in the London clay are the most impure of any, and contain on an average three times as much solid matter as deep Thames water. A good, pure, natural water is without odor, although the finer senses of some animals can detect it at a distance. Muddy water may be cleared by adding two or three grains of alum to a quart of it, then allowing it to subside. This effect is produced by the alum combining with the lime in solution, and forming an insoluble precipitate, which carries down other matter with it. For photographic use all natural waters should be well boiled and allowed to subside or be filtered.

Water purified by distillation is the best for all chemical purposes. It often happens that water sold as distilled water is far from pure, being contaminated by the vessels in which it has been stored, from the luting of the apparatus in distilling it, or from some other reason that could have been prevented by care. Good distilled water should be bright and odorless, and not show the least opalescence on the addition of silver nitrate. Should it be at all turbid or have the least smell, it may be safely concluded that it is impure, even if the silver nitrate test is satisfactory. Organic matter of some kind is in all probability contained in it. Lead is more easily corroded and dissolved by pure water than if it contains nitrate, carbonates and sulphates. Distilled water, therefore, should never be stored in lead receptacles; glass or well-glazed earthenware is best. Distilled water procured from the condensing engines of steamers or manufacturers' stationary engines is rarely free from oily matter; sometimes it is fairly good, but at others far from it. At any rate, it will not be wise to trust to the purity of water obtained from such sources.

The water supply of most large towns is tolerably

pure, but it should not be used for photographic purposes, such as development, without filtering it through two or three thicknesses of fine flannel, or swansdown calico. A bag of this material may be fixed over the supply tap and form a permanent filter. Taking it off and washing occasionally is all the attention required. It is surprising, even when the water seems bright and good, what a quantity of foreign matter will soon accumulate in this bag. It should also be boiled and allowed to stand before use. Many of the defects on negatives, and sometimes fogging, may be traced to the use of impure water, when its appearance may have been all it should be.

As a matter of course any defect in a lantern slide is enlarged; those that would pass muster in an ordinary printing negative would ruin a transparency; therefore any little extra trouble in ascertaining if the water is not at fault is amply repaid by the clear, neat and finished appearance of the slide.—Magic Lantern.

ORTHOCHROMATIC PHOTOGRAPHY.

AN article by Mr. Guerronan, in the Paris Photographer, entitled "Orthochromatism and Microphotography," will interest more than one of our readers, and so we give it in its entirety.

It is necessary in microphotography to reproduce an object invisible to the naked eye in such a manner that its external form and the most intimate details of its structure shall be rendered with perfect fidelity. This is quite easy with colorless objects, but the difficulty becomes almost insurmountable when it is a question of objects that are colored either naturally or artificially.

Mr. Monpillard, in a communication to the French Society of Photography, has given some hints that will greatly aid the operator. He advises the use of orthochromatic plates concurrently with colored screens. But, in order to put to profit all the achromatism possible, the author finds it more advantageous to prepare his own plates, which will thus possess a maximum of sensitiveness. Moreover, the manipulations are very simple and necessitate no new installation.

According to Mr. Monpillard, the following are the best formulas for the sensitizing baths.

For yellow, yellowish green and orange yellow:

MOTHER SOLUTION NO. 1.

Erythrosine B	1 gramme.
Distilled water	1000 grammes.

BATH FOR ORTHOCHROMATIC SENSITIZING.

Mother solution No. 1	4·0 c. c.
Distilled water	100·0 "
Ammonia	0·5 "

For red and orange red:

MOTHER SOLUTION NO. 2.

Cyanine	0·2 c. c.
Alcohol (95 per cent.)	100·0 "

This solution should be prepared fresh and kept in darkness.

BATH FOR ORTHOCHROMATIC SENSITIZING.

Mother solution No. 2	4·0 c. c.
Distilled water	100·0 "
Alcohol (95 per cent.)	5·0 "
Ammonia	1·5 "

In a very slightly lighted laboratory, immerse the bromogelatine plates in this bath for two minutes, the tray being meanwhile covered with a screen and shaken. Afterward, wash in three trays filled with distilled water, and dry in a hermetically closed closet containing a few pieces of chloride of calcium.

In order to have plates sensitive to yellow and red, they are first immersed for two minutes in a bath of erythrosine:

Mother solution No. 1	20 c. c.
Distilled water	80 "

and are then washed and immersed in the cyanine bath above mentioned. Baron Huebl, as a substitute for the cyanine, has recently recommended the use of Bengal rose (tetraiodide of fluorescine), the mother solution of which should have a bluish red tinge.

These plates give no fog. Mr. Monpillard has found that this accident is due to the alkaline bath that is generally used to increase the sensitiveness of the bromide of silver.

The sensitizing baths are not alone useful, for it is necessary to employ screens. We advise the use of trays that permit of utilizing all the substances that may prove useful and of graduating the rays that are too actinic. The following are some of these solutions for 100 parts of water. It is, however, very easy to graduate the strength of the solution according to one's needs:

TABLE A.

Color of Screen.	Substances.	Proportions for 100 Parts of Water.	Rays Absorbed.
Light yellow.	Neutral chromate of potash	1	Violet and blue.
Dark yellow.	Neutral chromate of potash	5	Absorbs violet completely.
Orange	Bichromate of potash	8	Absorbs violet and blue completely.
Red	Erythrosine	0·2	Absorbs yellow slightly.

We shall add to this list two products that have given results that we have been unable to obtain with the others in special cases. These are bromine and iodine in more or less dilute solution. These two bodies allow of the sensible passage of the red rays only, and necessitate a longer exposure. It is well to use them in the reproductions of subjects whose pale blue or violet coloration is juxtaposed to bright red or orange yellow. Mr. Monpillard gives the following further advice:

The focusing and exposure should be done in the same monochromatic light. During the exposure, two differently colored screens should never be allowed to intervene. This condition is necessary for the correction of chemical foci, save in the case of very dark red, in which the use of the screen is absolutely necessary. The plates treated with erythrosine and cyanine are extremely sensitive to blue and violet rays, as compared with the other colors. It is well to illuminate the object with a yellow or orange light, in order to moderate the action of the actinic rays.

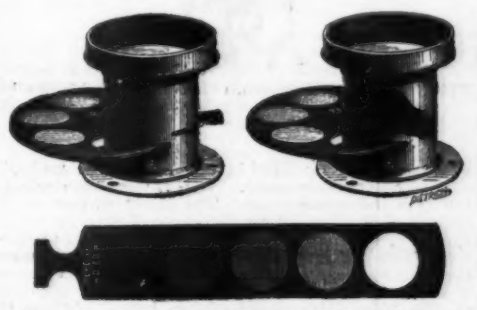
We reproduce herewith a table giving the principal cases found in ordinary practice, and that Mr. Monpillard has published in the Bulletin de la Société Française de Photographie:

TABLE B.

MONOCHROMATIC OBJECTS.		SCREEN.
Blue or violet, { Light, Dark,	Erythrosine bath,	Light yellow, dark yellow, or orange.
Green, yellow, orange yellow	Erythrosine bath.	Dark yellow or orange.
Orange red, red, dark red	Cyanine bath	Dark yellow or orange, orange, then red.

POLYCHROMATIC OBJECTS.		SCREEN.
Green and yellow	Erythrosine bath.	Dark yellow.
Green and red, yellow and red	Erythrosine bath.	Dark yellow, then red.
Green and red, yellow and red	Erythrosine and cyanine bath.	Dark yellow or orange.
Blue or violet with yellow.	Erythrosine bath.	Light or dark yellow, or orange, according to the intensity of the blue or violet.
Blue or violet with red.	Cyanine bath	The same; and continue with the red if necessary.

Let us remark that Table B serves absolutely for microphotography only, and that in the current reproduction it suffices, after an examination of the



DISK AND SLIDE FOR ORTHOCHROMATIC PHOTOGRAPHY.

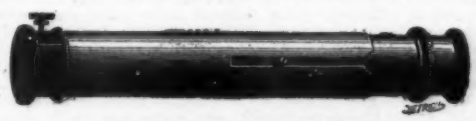
colors entering into the subject, to endeavor to extinguish the rays that are too actinic. This is easy enough upon consulting Table A, and upon using plates sensitized with solutions Nos. 1 and 2 for the least actinic color.

As regards Table B, it is intentionally that a plate sensitized for yellow is used for photographing an object of a blue or violet color. In microphotography it is useful solely to obtain the subject well detached from the background. In the case cited above, if an ordinary plate with a yellow screen were used, the whole of the luminous impression would be retarded, since the plate is not sensitive to the yellow rays. Therefore, plates sensitive to yellow are used concurrently with the yellow screen. Then the blue rays of the image being attenuated or absorbed, the yellow ground of the object becomes impressed to its true value, and the subject will detach itself in gray and black upon a light ground.

For objects of a yellow or red color, plates sensitive to these two colors are used, along with a red screen.

If the colors to be photographed include violet, yellow, and red, the difficulty becomes greater, yet surmountable despite this. The plate should always be sensitized for the least actinic color, and the blue and violet rays are, consequently, attenuated. This is a question of skill; and, with a little experience, it is easy to reach a perfect result.

In conclusion, we would advise that only a very



POCKET SPECTROSCOPE.

feeble red light be used in the laboratory, and that the plates, until complete fixing, be left exposed to such light for but a very short time.—Le Naturaliste.

POPULAR ERRORS ABOUT ELECTRICITY.

By C. C. HASKINS.

THERE is a large amount of brilliant ignorance abroad in the land as to the capabilities for good and evil of electricity, which leads people into serious, if not harmful, conclusions.

The trouble arises largely through a lack of distinction between "current" and "tension," terms which, to the public ears, are more readily comprehended if, in their stead, one should say mass or quantity and pressure or strain.

Where a larger amount of electric current passes in a given time, this flow is said to be one of more amperes, as one would say a larger pipe would discharge a greater number of gallons of water per minute, while a smaller sized pipe, as at the nozzle of a fire engine hose, might throw a stream of water very much farther by virtue of a much heavier strain or push behind it. One of these streams might thus furnish a great quantity at the delivery, and the other a comparatively small quantity at a very much greater distance away.

Now, one of these may be compared to a commercial current of electricity which is used by the electrotypers and platers. The flow of current is large, but the pressure is minimum. There is next to no necessity for careful insulation, for such a current has little tendency to escape; there is not that form of energy in its makeup. It is not potent for harm in the way of shocks; men handle it with perfect impunity. The surroundings of the electroplater's bath are wet; the men are wet, and their wet feet are in constant contact with the wet floor. The solution in which the plating is going on is a far better conductor of electricity than ordinary water, yet the attendants are constantly handling the metal articles, removing and replacing them without the slightest inconvenience. Here is a current of electricity capable of dissolving a metal which would withstand some thousands of degrees of heat in a furnace, carrying that metal in solution to the opposite pole of the bath and redepositing it in a metallic form on the article to be plated, yet a current which has not the element of push or pressure energy sufficient to propel a spark through the air across a space of one thirty-second of an inch—probably not one-half that. It is known to the electrical craft as a current of extremely low tension, a current of high quantity or high current flow. It is an extreme manifestation of one of the characteristics of an electrical current.

There is, on the other hand, a form of current which has a diametrically opposite character to this. It is possible to have a current of so much push or pressure that it is next to impossible to restrain it or keep it from escaping, even through the atmosphere. The flow from a frictional electric machine is of that character. The spark from one of these generators may be sent through the air (and air is one of the very best insulators known) two or three feet; it can be made to bore a hole through a plate of glass, and yet, although it may be discharged into a dish of gunpowder and blow the grains away, it is not at all certain that it will set them on fire. The spark which so many persons first saw developed last winter during the extreme cold weather by sliding across the carpet and touching the gas pipe is another example. The air in winter is far drier than in summer. Moisture makes the air a conductor, better in proportion to the amount of water it contains, and a small amount of moisture in the air is sufficient to prevent an accumulation of this high potential electricity. We cannot get these spark demonstrations in the summer season because of the moisture in the atmosphere, which serves as a vehicle for its escape.

Now for commercial use we have currents combining these two characteristics in different proportions. For telegraphic purposes, a certain amount of pressure is required, sufficient to push a small amount of current a long distance, but this pressure is not sufficient to permit it to dissipate itself in the surrounding air, except to a limited extent, save in a very misty rain.

The lines are insulated at every post, and the limbs of trees are cut away to prevent escaping current. There is only a very limited amount of current flowing, and while a considerable shock may be obtained from a telegraph current, there is little if any danger to life or property by contact with it.

A still lower level in the scale of risks is the current used by the telephone companies.

Ascending in the scale, we come to the low potential current used for lighting and power purposes. The pressure here is no heavier than on short lines of telegraph, the same virtually as with an ordinary blue vitriol or gravity battery of 50 to 110 jars. The difference between it and the telegraph current is in the characteristic of quantity, or current flow. It remains constant in pressure—usually 50 to 110 volts—but in proportion as openings for the flow are made, that is, as lamps are turned on or motors are brought into service, the increased demand is met by a greater supply, and the quantity is thus varied, while the push, the voltage, remains stationary. This pressure is not necessarily a dangerous one to life, and is not sufficient to force the current through more than a mere fraction of an inch of atmosphere. It produces an unpleasant sensation when received through the person, and is not safe to handle in a district where other and more powerful currents may be accidentally crossed with it. If a contact of good conductivity is made with the wire carrying this current, heat results, and without the safeguard known as the fusible metal, which acts on much the same principle as the soft plug in a boiler, and opens the circuit, the danger from electric lighting would drive it out of existence.

The next grade in the upward scale of voltage is that generated for street railway service—about 500 volts—which also remains constant in pressure, but varies in the output, according to the demand. This pressure, too, is incapable of jumping through a very short, dry air space, but it is a dangerous current to encounter.

Above this last in the scale comes the ordinary high tension arc system. This differs materially from the systems in which the quantity is variable but the pressure is constant. Here the quantity, or flow, is always the same, but the pressure varies, increasing with each additional lamp. These lamps require a pressure of from 45 to 50 volts each, but they do not vary the flow. Now, with ten lamps only in the line there would be 450 to 500 volts of pressure, and with 50 lamps there would be 2,250 to 2,500 volts, and even then the pressure is only a small fraction of what it is in the spark generated by sliding on the carpet, or the spark from the friction machine. But it has the other characteristic not possessed by these carpet-generated sparks. There is sufficient quantity or flow of current to make such a current extremely dangerous. It is the combination, if it may be so called, of high and low powers; that is, the possession of the two characteristics—volts and amperes—that makes this dangerous. It will kill, but it cannot jump an air space. It has pressure enough to require high insulation to restrain it, but the insulating properties of the atmosphere (which, when ordinarily dry, are far in excess of those of either glass, porcelain or India rubber) are proof, where this medium is as thin as an eighth of an inch, against the jumping of an electric light current, by virtue of its initial pressure.—Western Electrician.

THE warping effect of heat on lead pipes is shown by a recent case in an electric light installation where exhaust steam found its way into the ventilating and soil pipes leading to the drains. The effect was the warping of all the lead pipes so heated by the steam, says Industries and Iron. The heat caused the pipes to expand and warp, but when the steam was prevented from entering the drains the pipes did not contract and all had to be straightened by hand. Each time the pipes were heated they expanded, but in no case did they resume their normal condition.

[From Knowledge.]

THE FUNCTIONS OF THE HAIRS OF PLANTS.

By J. PENTLAND-SMITH, M.A., B.Sc.

THE merely descriptive botanist must exist in a paradise among the structures with whose functions we are about to concern ourselves, for their variety and beauty of form is almost endless. A consideration of their uses, however, and of their influence on the distribution of the plants which bear them, is a much more intellectual pleasure.

It must be confessed at the outset that, although in the majority of cases the biological significance of the hairs on plants is perfectly obvious, there are many instances in which it is impossible to conjecture their function.

Hairs may arise from any member of a plant—from the root, stem or leaf—and occasionally their presence may be observed in large internal spaces. In point of origin a hair is an epidermal structure—that is, it originates from a cell of the epidermis, or outer skin of the plant. The hairs of the root remain as simple prolongations of epidermal cells, but those found on other portions of the plant may develop in various ways, either remaining as single cells or becoming differentiated into two or more cells, which occasionally display a differentiation with regard to function.

The glistening hairs forming a downy covering on the leaves of certain plants owe their shiny appearance to the presence of air in their cavities. In many other cases the hairs of the leaf and stem at maturity contain protoplasm, a nucleus, and generally a large quantity of cell sap. The root hairs always belong to the latter category.

It would be an impossible task to compress into the limits of a short paper the many and varied functions performed by hairs, and the endless modifications of structure subservient to them. We shall content ourselves, then, with a fivefold physiological grouping of these structures, and shall give a few examples of each group.

I.—Hairs may be regarded as absorptive organs. The hairs of this class always retain their protoplasm, nucleus, and cell sap. The root hairs, as we have already noted, belong to it. Carbon, hydrogen, nitrogen, oxygen, phosphorus, potassium, magnesium, calcium, and iron are the elements from which the food of a green plant is produced. It normally obtains them all from the soil (with the exception of carbon and oxygen, which it derives from the air) in the form of compounds called mineral or inorganic salts, and water. The salts must be soluble in water or dilute acids to be available for the nutrition of the plant, as it is only in this form that the roots can absorb them. In search of these they ramify through the soil. The general surface of the root does not act as an absorbent; the root hairs alone perform this function. They contain solutions of organic acids which are denser than the solutions of inorganic salts in the soil, and a current is thus set up from the outside inward. It passes cell by cell to the interior of the root, where it enters the vascular bundles, which carry it up the stem to the leaves (see Fig. 1). It is to be specially noted in passing that this solution is very weak—it might be compared to tap water—as we shall have to speak by and by of the aid given by certain hairs to the process of getting rid of the excess of water.

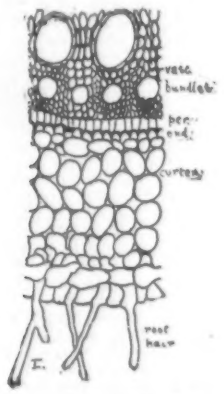


FIG. 1.—Transverse section of portion of root of maize (Zea mais); per. pericyle (from which young roots arise); end., endodermis, or bundle sheath; vasc. bundles, vascular bundles which conduct crude nutrient material from roots to leaves.

The root hairs by secreting organic acids help to dissolve, and so render available as food, salts insoluble in water. Roots can thus be made to trace out their course in the soil, if a polished slab of marble be placed at a suitable depth underground. It may be noted from Fig. 2, which is a semi-diagrammatic representation of the "rhizoids" and part of the stem of a very common moss (Funaria hygrometrica), that particles of soil are adherent to the large rhizoids (root hairs). As the specimen from which this was drawn was washed repeatedly in water and brushed with a camel's hair brush, it is evident that the hairs of the plant cling firmly to the soil particles. In addition, then, to absorbing water, they fasten the plant in the soil. The attempt to clean thoroughly the roots of a maize seedling will make this obvious to the reader. To obtain a specimen of it without injury to the root hairs, it is necessary to germinate the fruits in water or damp sawdust.

Negative evidence in support of the absorptive function of root hairs can be obtained by the examination of the roots of a water plant, such as Patamogeton, or the aerial roots of an epiphyte, such as an orchid. In the former there is no necessity for such organs, as the whole root is surrounded by water, and in the latter there is a special modification of the cortical and epidermal cells, enabling these plants to condense and absorb the moisture of the air. In the case of a few epiphytes, however, the presence of root hairs must be noted, but the plants bearing them grow in damp, shady situations, where there is no chance of these delicate organs being dried up.

Root hairs are very short lived. As the roots increase in length, new root hairs are developed at a short distance behind the growing point, and the old ones die off. The plant is thus continually brought into contact with fresh sources of food.

In higher plants the absorption of water by the stem and leaves is the exception, not the rule. The outer layers of the epidermal cells are, moreover, less impervious to water, being infiltrated with a substance called cutin, or covered with a coating of wax, which renders them quite impervious.

We shall now cite a few instances in which the epidermal cells are modified into hairs that act undoubtedly as absorptive organs. One of the most curious is found in the common ash. The upper surface of the midrib of the leaf is deeply grooved, the lips of the groove meeting above except at the points of origin of the leaflets. Water falling on the leaflets runs into the tube at these points, and once entered, its evaporation is prevented. From the under surface and sides of the tube arise multicellular hairs. When the transpiration of water from the leaf exceeds the supply brought up from the roots, these hairs absorb the water in the tube. Thus there is a guard against desiccation of the leaf.

FIG. 2.—Lower portion of stem and "rhizoids" of Funaria hygrometrica. Notice the soil particles clinging to the hairs.

The common chickweed (Stellaria media) is an annual plant that abounds as a weed in cultivated places. Its native habitat is the banks of streams and road sides. It is quite devoid of hairs excepting a ridge down one side, between the pairs of opposite leaves, as seen in Fig. 3. Long hairs are also borne on the margins of the petioles or leaf stalks. After a shower of rain the surface of the leaves is quite dry, but the water is retained by the ridge of hairs. Let us consider more fully the action of these bodies. If the supply of water is in excess of what can be retained by the hairs of the uppermost ridge, it flows to the pair of opposite leaves situated immediately below, where a certain amount is held by the ciliate hairs of the petioles, while the superfluous supply flows down to those on the ridge below, and so on. A quantity of water thus bathes the bases of the hairs on the stem and leaves. The hairs are multicellular filaments, with nucleus, protoplasm and cell sap. The upper cells, according to Kerner, do not absorb water, but it passes through the basal cell walls, and is absorbed by the protoplasm and passed on to the interior of the stem or leaf. As proof of this, he instances the fact that when the water has dried off the ridges the cell walls of the basal cells exhibit a striated appearance, which can only be accounted for by supposing a loss of water from their interior. A good absorber is a good transpirer, unless special provisions are made to prevent transpiration. The basal cells, then, having no special protection, exhale in dry weather the water they previously absorbed in wet.

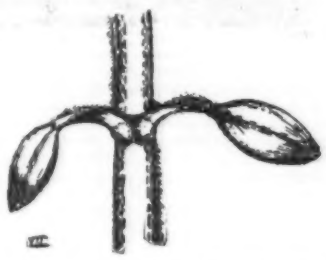


FIG. 3.—Portion of stem of Stellaria media (chickweed), enlarged. Notice the unilateral ridges of hairs, and the hairs on the petioles.

It is somewhat difficult to account for the use of the extra supply of water in this case. Many plants growing by the banks of streams are likewise endowed. In damp situations it would appear at first sight that such a supply is superfluous. Perhaps Kerner's explanation, put forward for similar cases, and which seems to be the only one forthcoming, is the correct one. Nitrogen is one of the main constituents of plant food. As we have stated, a green plant normally obtains it from the soil in the form of soluble inorganic salts. This constituent of food is lacking in sufficient quantities in marshy situations, hence we find plants like Drosera (sundew) and Pinguicula (butterwort) inhabiting these regions, endowed with capturing and digestive apparatus enabling them to obtain nitrogen from the bodies of living animals, which they retain, kill and then digest.

Certain members of the pea tribe are able to make use of the nitrogen of the air (see March and April numbers of Knowledge, 1894) as a source of food, but it has never been contended that there is any reason to suppose that other higher plants are likewise endowed. In the air, however, ammonia and nitric acid are present in very small quantities. They are carried to the soil by rain water, and it has been estimated that from four to twenty pounds of nitrogen in the form of nitric acid may be distributed annually over an acre of ground by the rainfall. May it not be the case, then, that the tiny droplets of water retained by the leaves of this plant after every shower of rain contain in the aggregate a supply of nitrogen sufficient to make up for the deficiency in the soil, which, being absorbed in the manner indicated, materially benefit the plant?

A very pretty contrivance for absorption and retention of water is seen on the under surface of the leaves of the Alpine rose (Rhododendron hirsutum). It consists of a number of multicellular hairs, each shaped like a disk, supported by a short stalk. Each hair is lodged in a depression on the under surface of the leaf, generally situated below a vein. The cells of the glandular hairs secrete a resinous matter that forms a brown incrustation on the under surface of the leaf.

When rain falls on the upper surface it soon reaches the under surface, partly by the agency of the marginal hairs. This results in the swelling up of the resinous material and the absorption of water by the glands. In dry weather the resin, drying up, encrusts the glandular hairs and thus prevents evaporation from their surface.

Similar provisions for the absorption of water during wet weather, and its retention during dry periods, are marked in the family of the Saxifrages. In Saxifraga aizoon, the evergreen saxifrage, the small somewhat fleshy leaves are deeply serrated, and on the upper surface of each tooth there is a well marked depression, whose base is lined with cells secreting carbonate of lime. The presence of this substance gives quite a grayish-white appearance to the leaf margin. The incrustation is held in its place by knobbed hairs that arise from certain of the epidermal cells.

This saxifrage, in common with its allies, is found in rocky situations, where, subjected to the action of a strong sun, it stands much chance of desiccation. The incrustation of lime serves to prevent the evaporation of water, but when rain comes it soaks under the crust, and the delicate-walled secreting cells can now act as absorbents. In dry weather the crust sinks down again and plugs up the cavity, but it often happens that, even with these provisions, the leaf becomes so dried up that it curls upward, thus cracking the lime stoppers, which would be easily blown away by a strong wind were it not that each is held in place by the hairs whose presence we have already mentioned.

The stem and leaves of the Pelargoniums (the "Geraniums" cultivated in our glass houses are really Pelargoniums) bear numerous unicellular and multicellular hairs. Two forms of these are represented in Fig. 4. In many cases the latter are more swollen at the tip than the specimen to the left of the figure, and they then receive the name of capitate hairs. The outer wall of the apical cell is very thick, but in wet weather it swells up and becomes converted into a resinous material, which peels off, and permits of the passage of water into the interior of the cell. The resinous matter is secreted by the cell, and is bounded on the outside by a thick layer of cuticular substance, which peels off with it. Then the cell secretes a fresh supply of resinous substance that hardens as the weather becomes dry and so prevents evaporation from the outer surface of the hairs.

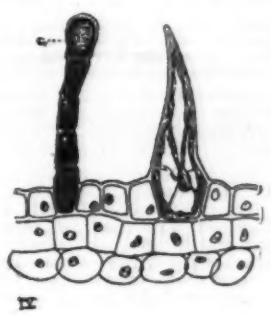


FIG. 4.—Portion of epidermis and underlying tissue of Pelargonium, with secreting hair (c), and a sharp pointed hair.

II.—Hairs also function as maintainers of a free passage for the flow of water vapor from the stomata. The very dilute solution of nutrient salts absorbed by the root hairs passes up the stem chiefly through the special conducting layers of tissue called the vascular bundles, whose terminations are the veins of the leaves. From the leaves the superfluous water is evaporated, not from the general surface, for that, as we have seen, is more or less impervious to water, but by specially modified organs called stomata (Greek στωμα, a mouth). If the evaporation of water be retarded, it stands to reason that the plant will receive less nourishment than when the process is being actively carried on. Any obstacle, then, that prevents the free transpiration of water will be detrimental to its growth. Thus, any contrivance which prevents the blocking up of the stomata, by water or other substances, will be more or less effective in promoting the development of the organism.

The leaves of Nerium oleander (the oleander), a plant commonly grown in our glass houses and much used during summer for outdoor decoration on the Continent, have their stomata situated at the base of deep pits in the under epidermis.

The entrance to these is guarded by a large number of comparatively long unicellular hairs, that arise from the sides of the cavities. A transverse section of a portion of an oleander leaf is represented in Fig. 5; st. are the stomata and h the hairs; ep. is the epidermis of the under surface. A surface view of a portion of the epidermis is shown in Fig. 6, the lettering being the same as for the previous figure. The hairs are not wetted by moisture. They prevent water which may pass to the under surface of the leaf from block-

ing up the stomatic orifices. As the oleander grows in damp situations, transpiration, and consequently growth, would be retarded were there not some means of preventing the excessive moisture to which it is subjected in its native habitat (the banks of streams

FIG. 5.—Transverse section of portion of leaf of oleander (Nerium oleander), with pit on lower surface; st., stomata; h, hairs.

and similarly moist situations in Southern Europe) from blocking up the stomatic orifices by drops of water.

This is exemplified in a still more remarkable manner by the rolled leaves of Azalea procumbens, and Kerner states that it is common to rolled leaves from all parts of the world. In Azalea procumbens, the

FIG. 6.—Surface view of pit, with hairs and stomata of the foregoing.

trailing azalea, the leaf is rolled inward, as shown in Fig. 7. There is a marked ridge of tissue below the vascular bundle of the midrib, dividing the under surface of the leaf into two well defined longitudinal grooves. From the under surface of the epidermal cells depend filamentous processes of the cuticle, which, perhaps, strictly speaking, we should not term true hairs, as they are solid, not hollow.

This species of azalea grows in situations where the underlying soil is moist for the greater part of the year and thus renders transpiration from the leaves a matter of difficulty. Hence it is necessary that, when bright, sunny weather does make its ap-

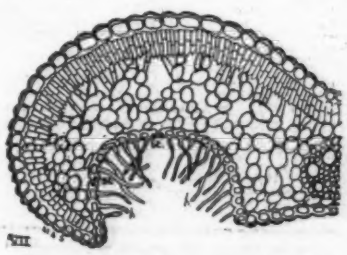


FIG. 7.—Transverse section of half of a leaf of Azalea procumbens. St., stomata; h, cuticular processes —"hairs" of epidermal cells.

pearance, the plant should be able to take full advantage of it. This is effectually provided for by the arrangement in question. Moisture does not wet the hair-like cuticular processes, and so the passage of water into the stomata is prevented, and a clear air space is maintained around the stomatic orifices.

III.—A third function performed by hairs is that of protection. There are innumerable instances in which hairs or hair-like structures have evidently arisen for this purpose. The ordinary hawkweed (Hieracium pilosella) affords us a good example of this. It is a plant belonging to the natural order Compositæ (the daisy order), and resembles a dandelion in some respects. It is widely distributed in Britain. The under surface of its leaves is covered with hairs that have lost their protoplasmic contents and whose cavities are filled with air. Air, as is well known, is a bad conductor of heat. The greater the heat the greater the transpiration, and conversely a decrease in temperature involves a corresponding decrease in evaporation, other conditions remaining the same. Thus the hairs of this plant form an effective screen from the solar rays and lessen the amount of transpiration. That this is the function of these structures is fairly apparent. The ground in which the plant grows frequently dries up, and then it is found that the leaves curl upward, and so expose their felted under surface to the sun, thus effectively lessening the chance of desiccation.

A still better example of a plant provided with protective hairs is the edelweiss (Gnaphalium leontopodium), which grows in the Alps at a height of from five thousand to six thousand feet. Its leaves appear like tufts of wool, so densely are they clothed on both surfaces with long multicellular hairs filled with air. The cuticle of the epidermal cells is thin, and thus affords no protection to excessive transpiration. These hairs not only form an effectual safeguard in this respect, but also protect the plant in a very efficient manner from frost and cold.

The epidermis of the leaf of Eleagnus is covered with large stellate hairs, as is shown in Fig. 8, which have a

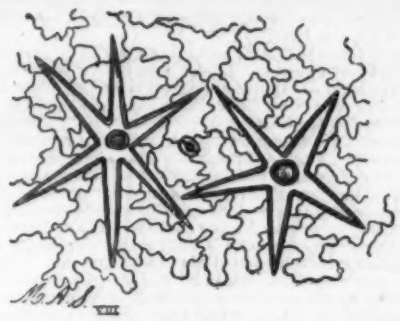


FIG. 8.—Under surface of leaf of Eleagnus, with stellate hairs.

similar protective function; but a more remarkable example of a plant with leaves covered with protective structures is the Rochea (Saxifraga) falcata, a native of South Africa. The hairs of this plant assume the form of enormously swollen bladders. The leaf is very succulent and the ordinary epidermal cells are thin walled. The walls of these bladder-like hairs are impregnated with silica, and the bladders fit into one another so as to form a complete siliceous coat to the surface of the leaf. They thus effectually protect the desiccation of the underlying tissue. By careful focusing a distinct nucleus may be observed in some of these swollen cells, implying, of course, the presence of protoplasm and cell sap, and showing how effectually the flinty armor performs its work. A transverse section of the epidermis from the leaf of Rochea is shown in Fig. 9.

A very effective coating of protective hairs is ex-

FIG. 9.—Transverse section of upper part of epidermis of Rochea (Saxifraga) falcata, with bladder-shaped hairs (h), whose walls are impregnated with silica; ep., ordinary epidermal cell; st., stoma.

hibited by the male shield fern (Nephrodium filix-mas). The young leaves and the upper part of the stem are densely covered by innumerable scaly hairs, sometimes termed ramenta, destitute of cell contents. These must be especially serviceable in shielding the plants from the injurious effects that follow sudden changes of temperature, and they protect the delicate growing portion from cold and excessive moisture.

The deposition of pollen upon the stigma is called pollination, and there are many contrivances to prevent self-pollination, and also many others to insure cross pollination—that is, the deposition of pollen from another plant (of the same species). In certain cases it has been shown that the seeds produced as the result of cross fertilization are more numerous and superior to those resulting from self-fertilization. Cross pollination is often effected by insects, and to attract them plants may go to the expense of secreting nectar. But the sweet juice attracts insects that are too small to effect the work of cross pollination, as well as effective larger ones. If the former succeed in obtaining the coveted secretion, the plant will have spent its energies in vain. Means are, therefore, taken to frustrate the attempts of these small animals at visiting the flowers, and hairs are often the agents thus employed. These hairs pour forth a sticky secretion in which the unwary insect becomes entrapped and meets an ignominious death. As an example of this we may cite the Silene muscipula, or catchfly, a very common British plant belonging to the natural order Caryophyllaceæ (the pink order), which has received its name from this circumstance. The sticky hairs are only developed on and near the floral region of the stem and offer an effective trap for unwelcome guests.

IV.—A fourth use to which hairs are subservient is again connected with the pollination of flowers. In some cases the hairs prevent self-pollination; in other instances they are the active agents in effecting it. The Compositæ afford us very good examples of both cases. The plants belonging to this order are characterized by the possession of five stamens attached to the petals, whose filaments are free from one another, but whose anthers are united into a tube. The upper part of the style is bifurcated, but the forks are at first closely apposed and their outer surface is covered with hairs. The inner surface of each fork is the stigmatic surface. The upper part of the style is inclosed by the anthers while the flower is young, but by and by an increase in the length of the style occurs, causing the upper hairy portion to push its way through the anther tube like a bottle brush, dislodging the contained pollen grains, which may fall on neighboring flowers or be carried off by insects. In this way their self-pollination is prevented; but afterward the lobes of the style turn backward, bringing part of the stigmas into contact with some of the lower hairs on which pollen grains are still adherent. Thus self-pollination may take place if cross pollination has not been effected.

V.—Hairs are of great use in aiding the dissemination of fruits and seeds. Every one knows the fruit of the dandelion, with its long stalk, bearing a crown of long delicate hairs that enable it to be wafted considerable distances by the wind. Then, again, the seeds of the willow herb (Epilobium) are furnished with beautiful white hairs, which act in the same manner as those of the dandelion.

Instead of losing their cell contents like those we have cited, the hairs may remain succulent, and thus help to produce a pulpy fruit, which, attracting birds and other animals, acts indirectly in the dissemination of the seed. The orange is a good example of such a case. The pulpy portion is wholly composed of enormously long unicellular hairs.

THE DEPTHS OF SPACE.

By Prof. ROBERT S. BALL.

OF all the sciences, there is none which makes such vast demands upon the powers of the human imagination as the science of astronomy. We have to brace our minds to the conception of distances and magnitudes so utterly transcending all ordinary human experience, that special means have to be invoked to render them intelligible. Each advance in our knowledge of the heavens reveals to us the grandeur of the celestial spaces on an ever-growing scale.

I propose to give in this paper some illustrations of what is known with regard to the distances of the stars, and I shall naturally take the opportunity to make special use of certain recent advances by which our knowledge of the subject has been greatly extended. First let me say that the task of finding the distance of a star involves the most delicate piece of measurement that has ever been undertaken.

The great majority of the stars are situated at distances so enormous that it is utterly hopeless to attempt to determine how far away they are. In fact, only comparatively few stars happen to lie sufficiently close to the earth to permit of our making any accurate determination of their positions. Nor is it by any means an easy task to choose out those particular objects which do lie within range. It not unfrequently happens that after much labor has been expended on observations of some particular star, it has been found that the work is fruitless, and that the star is so remote that there is no possibility of learning what its distance actually amounts to. Much care must, therefore, be taken to make a judicious selection of the particular star to which it is proposed to devote so much time and labor. It might naturally be supposed that the brightest stars are those nearest the earth; and no doubt, if all the stars were intrinsically equally bright, their apparent brightness would be a safe guide in placing these objects at their true relative distances. For in this case the only explanation of the endless varieties of luster which stars exhibit would be that some of them are much nearer to us than others. But there is no such simple connection between brightness and proximity as this would imply. We know that the very brightest star in the heavens is Sirius, but we also know that Sirius is by no means the nearest neighbor of the solar system. Recent researches have also shown us that the famous star Arcturus, the brightest member of the constellation Bootes, and one of the three or four most beautiful stars visible in our northern skies, is by no means one of the stars comparatively near us. Arcturus has, in fact, been recently shown to be so excessively far off that it must be classed with those stars whose remoteness renders it impossible for us ever to learn what their distance actually amounts to.

There is, however, another indication of position which is very frequently accepted by astronomers when discussing whether a star is likely to lie within such a degree of proximity to the earth as to make it worth their while to try to determine its distance. When we are looking at a steamer near the horizon the vessel seems to change its place but slowly, though we may know as a matter of fact that it is traveling at a rate of perhaps more than ten miles an hour. The nearer we are to the steamer the more rapidly does it seem to move. In like manner, if a star were animated by what is called proper motion, that is to say, if the star shifted its position on the sky with reference to the other stars, and if the amount of this shift was unusually great, then there would be a presumption that the star was comparatively near. It will, indeed, be obvious that if all the stars were really traveling at the same speed, those which lie nearest the earth would move over an appreciable part of the sky in a shorter time than those which were more remote. Of course, we are not entitled to assume that the stars are moving with equal rapidity in space. Indeed, we know well that such is not the case. But, speaking generally, we may fairly argue that if a star does appear to be moving rapidly, it is a presumption that that body is one of the sun's nearer neighbors.

The star whose distance is to be sought having been chosen, an elaborate series of observations has then to be undertaken. The astronomer measures in his telescope the sky interval by which that star is separated from a neighboring star, which, though apparently close by, is in reality much farther away. Indeed, for this auxiliary star we like, if possible, to have an object which is about ten times as far as the comparatively near star. It is, however, essential that the two shall lie so nearly in the same direction as to be both visible together in the same telescope field. By means of a delicate instrument applied to the telescope we measure the width of the bit of sky between the two stars, and these measurements are repeated night after night for a twelvemonth. This year's series of observations is absolutely necessary, for the astronomer is gradually shifting his own position, and in six months' time this shift will amount to nearly 200,000,000 miles, the earth having moved during this period round to the opposite point of its orbit. The displacement of the observer alters the position of the near star in relation to its more distant companion. We thus find that the sky interval between the two objects changes periodically, and from observations such as these it is possible, by the magic of mathematics, to determine the distances of some of the stars from the earth.

So far as astronomers have yet learned, the star

which lies closest to the earth is one which we do not know in the northern hemisphere, though it is very familiar to residents in southern latitudes. This star is the brightest gem in the constellation of the Centaur, and according to the usual mode of designation, it is spoken of as Alpha Centauri. The telescope shows the object to consist of a pair of magnificent suns slowly revolving each around the other, and animated by movements in the same direction through the sky. Many attempts have been made to determine the distance from us of this celebrated pair of objects. Its distance has been measured by Dr. Gill, Her Majesty's astronomer at the Cape of Good Hope, and by Dr. Elkin, of Yale Observatory, New Haven, with all the accuracy which modern science permits.

I do not here propose to state the distances of the stars in miles. No doubt strings of figures for this purpose might be written down, and they have of course a value in their proper place. Instead of repeating such figures, I shall endeavor to translate them into ideas more suitable for conveying a due appreciation of the magnitudes involved. The electric telegraph will supply an illustration for the purpose.

Every one knows the unparalleled swiftness with which an electric signal speeds its way along a conducting wire. The operator presses the key, and instantly an electric flash is transmitted from one end of the country to the other. The merchant, on going to his office after breakfast, dispatches a message to a place thousands of miles distant, and easily receives his answer before the morning is over, notwithstanding the inevitable delays incidental to the transmission and the reception of the message. The speed at which the current actually travels is indeed so great that very elaborate instruments are required if that speed is to be measured. Only an imperceptible fraction of a second would be occupied in an electric journey across a continent. The actual velocity attained in telegraphic practice varies according to circumstances. The electrician, however, knows that, even when all the circumstances are most favorable, the speed of a current along the wire could never exceed 180,000 miles a second. We shall employ this maximum speed as the velocity of electricity in our present illustration.

Just consider all that this implies. Suppose that a row of telegraph posts 25,000 miles long were erected round the earth at the equator. Suppose that a wire were stretched upon these posts for this circuit of 25,000 miles, and that then another complete circuit was taken with the same wire around the same posts, and then another and yet another. In fact, let the wire be wound no fewer than seven times completely about this great globe. We should then find that an electric signal sent into the wire at one end would accomplish the seven circuits in one second of time. Provided with this conception, we can now give suitable illustrations of the results at which astronomers have arrived in their researches on the distances of the stars.

Let us suppose that the telegraph lines, instead of being merely confined to the earth, were extended throughout the length and depth of space. Let one wire stretch from the earth to the moon, another from the earth to the sun, another from the earth to the nearest bright star, another from the earth to a faint telescopic star, and finally let a wire be stretched all the way from the earth to one of the more distant stars. Let us now see what the very shortest time would be in which a message might be transmitted to each of these several destinations. First, with respect to the moon, our satellite is comparatively speaking so near to us that but little more than a second would be required for a signal to travel thither from the earth. The sun is, however, many times further away than the moon, and the time required for sending a message to the sun would be correspondingly longer. The sun is indeed so far that when the key had been pressed down, and the electric wave had shot forth along the solar wire to pursue its route at that stupendous speed which would permit it to place a girdle seven times around this earth in a second, yet eight minutes would have to elapse ere the electric wave, notwithstanding its unparalleled velocity, had passed from the earth to the sun. An answer sent back from the sun would require another eight minutes for the return journey, so that if there were no undue delay in the solar post office, we might expect a reply within half an hour or so after the original message had been dispatched.

Telegraphing to the stars would, however, be a much more tedious matter. Take first the case of the very nearest of those twinkling points of light, namely Alpha Centauri, to which I have already referred. The transmission of a telegraphic message to this distant sun would indeed tax the patience of all concerned. The key is pressed down, the circuit is complete, the message bounds off on its journey; it wings its way along the wire with that velocity sufficient to carry it 180,000 miles in a single second of time. Even the nearest of the stars is, however, sunk into space to a distance so overwhelming that the time required for the journey is not a question of seconds, or of minutes, not of hours, not of days, not of weeks, nor even of months, for no less than four years would have to pass before the electricity, trembling along the wire with its unapproachable speed, had accomplished this stupendous journey.

Alpha Centauri is, however, merely the nearest of these stars. We have yet to indicate the distances of those which are more remote. Look up to-night toward the heavens, and among the thousands of twinkling points which delight our eyes there is many a one up there so far off that if, after the battle of Waterloo had been won in 1815, the Duke of Wellington had telegraphed the news to these stellar depths, the message would not yet have been received there, notwithstanding the fact that for eighty years it has been flashing along with that lightning velocity which would carry it seven times round the earth in the interval between the two ticks of a clock.

There are stars further still. Fortify your eyes with a telescope and direct it toward the sky. Myriads of stars will then be revealed which would not be discerned without its aid. Nor need we feel surprised that the effulgence of glorious suns, as these spheres undoubtedly are, should shrink to such inconsiderable proportions when we think of the awful remoteness of these bodies. Over our heads there are thousands of stars so remote that if the news of the discovery of America by Columbus had been circulated far and wide though the universe by the instrumentality of the telegraph, these thousands of stars to which I now refer are elevated into boundless space to altitudes so stupendous that the announcement would not yet have reached them.

And we have still one more step to take. Let us think of the telegraph wire that is supposed to run from the earth to one of those stars which are only known to us by the impressions they make on a photographic plate. It seems certain that many of these stars are so remote that if the glad tidings of the first Christmas at Bethlehem, 1894 years ago, had been disseminated through the universe by the swiftest electric current ever known, yet—those stars are so inconceivably remote—all the seconds which have elapsed in the 1894 years of our present era would not have sufficed for the journey.

Some there are who may be inclined to doubt these facts, and of course to doubt wisely is a most wholesome attitude to take with respect to all scientific work. But if any reader of these lines should entertain any misgivings as to the reality of these stellar distances, then there is one consideration which I specially commend to his notice. Remember that space seems to us to be boundless, for our imagination can conceive no limits. There must, it would seem, be depths of space thousands of times, or indeed millions of times, greater than those of which I have spoken. We can conceive of no boundary; for even if that celestial vault of crystal existed which the ancients supposed, our imaginations could pierce through it to the other side, and then in thought we could start afresh, and on and on indefinitely. And seeing that space seems to us to be infinite, what wonder is it if the stars should lie at the distances I have named, or at distances millions of times greater still? Indeed, I would rather say that we have good reason to feel thankful that so many of the stars have come so near to us as to allow of their being glimpsed by our eyes, or caught on our photographic plates. There is ample room to permit of their retreat so far into space that the heavens would have appeared an absolute void, instead of presenting that glorious spectacle which now makes our nightly skies an abounding delight.—N. Y. Sun.

PREVENTION OF POTATO DISEASE.

THE Irish Land Commission has circulated a leaflet giving instructions for the application of the mixture of copper sulphate and lime, known as Bordeaux mixture, to the potato crop for the prevention of disease, from which we take the following general remarks:

1. The first dressing should be applied before signs of disease are observed on the crop. It is, therefore, desirable that the first dressing should take place a few days before the period at which disease usually makes its first appearance in the locality; the period of application of the first dressing would, therefore, vary from the beginning of June in early districts to the middle or end of July in late districts. The best results will be obtained by dressing the crop before disease is observed, but considerable benefit will generally accrue if the dressing is applied immediately after disease has been observed. Little, if any, benefit will be derived by applying the dressing after the disease has spread pretty generally over the foliage.

2. The best results will be obtained by spraying during dry weather; if rain should fall heavily soon after spraying, examine the foliage, and if the mixture has been washed off to a considerable extent, spray again.

3. The Bordeaux mixture should be well stirred with a stick on each occasion before drawing a fresh supply for the spraying machine.

4. The external bearings and working parts of knapsack spraying machines fitted with rubber valves should be frequently lubricated with pure vegetable oil. Olive oil is suitable; ordinary lubricating oils generally contain paraffin, which injures India rubber. They should not, therefore, be used for spraying machines fitted with rubber valves.

5. One man attended by a boy can apply about nine or ten gallons of dressing with a knapsack spraying machine in one hour. One boy can attend three men using knapsack sprayers, carrying fresh supplies of dressing to them. Three men, attended by a strong lad, should spray a statute acre of potatoes in about five or six hours.

6. The quantity of the mixture to be applied per acre is approximately as follows, a 2 per cent. mixture when prepared costing about one halfpenny per gallon: For an average crop of Champions with fully developed foliage, 100 gallons per statute acre, 100 gallons per Irish acre; for a crop of Champions with more than the average amount of foliage, 150 gallons per statute acre, 240 gallons per Irish acre; for a crop of Champions with a small development of foliage, 80 gallons per statute acre, 130 gallons per Irish acre.

7. In the experiments carried out by the Irish Land Commission during the years 1892 and 1893 the plots sprayed with a 2 per cent. mixture gave, on the whole, better results than those sprayed with a 1½ per cent. mixture, but the difference in favor of the 2 per cent. was slight. It is probable that in the case of coarse-leaved varieties, such as the Champion, the best results will be obtained by using a 2 per cent. mixture, but in the case of more tender-leaved varieties, or when the foliage is very young at the time of spraying, it would be advisable to spray with a 1½ per cent.

THE ELECTRIC LIGHT BUG.

WHAT is now called the electric light bug was first seen in Chicago—the city that uses more electric lights than any other in America and that was one of the first to use them generally. These bugs are now a positive nuisance there. Millions of them lie on the sidewalks of the main streets, to be crushed under the feet of the pedestrians. A great many fall upon their backs and lie in that position, wriggling their feet in vain endeavors to turn over. The others are almost as helpless. They seem to have stunned or crippled themselves by flying against the lamp globes. The spread of this pest has been very wonderful. They were first noticed in Chicago only two years ago, yet to-day they are beginning to be seen in Cleveland, Buffalo and Boston, and are very numerous in such summer resorts as Asbury Park, Atlantic City and Long Branch. They are roaches, apparently of the same genus as the cockroach, but larger, flatter and of the color of glue. There must be something in the optics of these vermin that makes the electric light specially attractive for them.

ON January 18 the seismometrograph at the observatory in Rome measured five complete pulsations of slow period characteristic of earthquakes at a great distance. On the same day, forty-nine minutes earlier, a severe earthquake was felt on the east coast of Japan, nearly 6,000 miles away. The pulsations traveled at the rate of 1,987 miles a second.

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